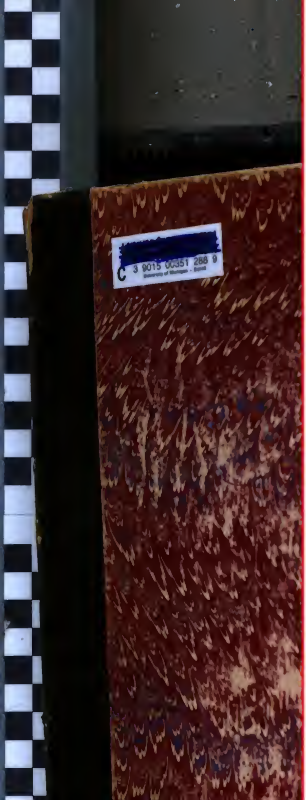
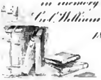
ENCYCLOPAEDIA
BRITANNICA



[redacted]
C 3 9015 00351 288 9
University of Michigan - Books

C 3 9015 00351 288 9
University of Michigan - BUHR

Library of the University of Michigan
The Coyl Collection
Miss Jean L. Coyl
of Detroit
in memory of her brother
Col. William Henry Coyl
1894.



AE
5
E36
1771

THE NEW VOLUMES

OF THE

ENCYCLOPÆDIA BRITANNICA

11737

THE

NEW VOLUMES

OF THE

ENCYCLOPÆDIA BRITANNICA

CONSTITUTING

IN COMBINATION WITH THE EXISTING VOLUMES OF THE NINTH EDITION

THE TENTH EDITION

OF THAT WORK, AND ALSO SUPPLYING

A NEW, DISTINCTIVE, AND INDEPENDENT

LIBRARY OF REFERENCE

DEALING WITH RECENT EVENTS AND DEVELOPMENTS

THE FIRST OF THE NEW VOLUMES, BEING

VOLUME XXV

OF THE COMPLETE WORK

PUBLISHED BY

ADAM & CHARLES .
BLACK, EDINBURGH
& LONDON . . .

'THE TIMES' . .
PRINTING HOUSE
SQUARE, LONDON

MCMII

THE EDITORS

SIR DONALD MACKENZIE WALLACE,
K.C.I.E., K.C.V.O.

ARTHUR T. HADLEY, LL.D.,
PRESIDENT OF YALE.

HUGH CHISHOLM, B.A.
(FORMERLY SCHOLAR OF C.C.C. OXFORD)

THE DEPARTMENTAL EDITORS

FOR LAW AND GOVERNMENT:
THE HON. SIR JOHN SCOTT, K.C.M.G., Deputy Judge-Advocate-General.

FOR MILITARY AFFAIRS:
SIR GEORGE SYDENHAM CLARKE, K.C.M.G., F.R.S.

FOR MEDICAL SCIENCE:
D. NOEL PATON, M.D., B.SC., F.R.C.P.ED.

FOR THEOLOGY:
REV. W. E. COLLINS, M.A., Prof. of Ecclesiastical Hist. at King's Coll., Lond.

FOR MINING:
HENRY M. HOWE, A.M., Prof. of Metallurgy at Columbia University.

FOR BOTANY:
D. H. SCOTT, M.A., PH.D., F.R.S., Hon. Keeper, Jodrell Laboratory, Kew.

FOR GEOGRAPHY AND STATISTICS:
J. SCOTT KELTIE, F.S.S., F.S.A.SCOT., LL.D., Sec. Roy. Geog. Soc.

FOR ASTRONOMY:
SIMON NEWCOMB, PH.D., LL.D.

FOR MATHEMATICS:
JOSEPH LARMOR, M.A., D.SC., SEC.R.S., University Lecturer in Mathematics, Cambridge.

FOR ELECTRICITY:
J. A. FLEMING, M.A., D.SC., F.R.S., Prof. of Electrical Engineering, Univ. Coll., London.

FOR ART:
M. H. SPIELMANN, Editor of the *Magazine of Art*.

FOR ZOOLOGY:
G. HERBERT FOWLER, PH.D.

FOR NAVAL AFFAIRS:
JAS. RICHARD THURSFIELD, M.A.

FOR BIOGRAPHY:
RICHARD GARNETT, C.B., LL.D.

FOR LITERATURE:
EDMUND GOSSE, LL.D.

FOR ECONOMICS:
WYNNARD HOOPER, M.A.

FOR RAILWAYS:
MAJOR HENRY G. PROUT, Editor of *Railroad Gazette*, N.Y.

FOR MUSIC:
J. A. FULLER MAITLAND, M.A., F.S.A.

FOR GAMES AND SPORTS:
ALFRED WATSON, Editor of the *Badminton Library*.

THE ASSOCIATE EDITORS

PHILIP A. ASHWORTH, DR. JUR.
H. M. ROSS, B.A.

FRANKLIN H. HOOPER, A.B.
E. H. WILLIAMS, M.D.

THE SUB-EDITORS

JAMES A. MANSON.
G. B. LYNES, A.M.

Copyright, 1902, by The Encyclopædia Britannica Company.

ENCYCLOPÆDIA BRITANNICA.

VOLUME XXV (AACHEN—AUSTRALIA).

PRINCIPAL CONTENTS.

ABDURRAHMAN KHAN. Sir Alfred Lyall, K.C.B., G.C.I.E.

ABYSSINIA. *History*, Count Gleichen; *Geography*, Professor A. H. Keane, F.R.G.S.

ABYSSINIAN CHURCH. A. J. Butler, M.A., Fellow of Brasenose College, Oxford.

ACADEMY, ROYAL. F. A. Eaton, Secretary of the Royal Academy.

ACADEMY, FRENCH. Edmund Gosse, LL.D.

ACCOUNTANTS. J. G. Griffiths, ex-President of the Institute of Chartered Accountants.

ACCUMULATORS. W. Hibbert, F.I.C., F.C.S., Assoc. M.Inst.E.E.

ACETYLENE. Vivian B. Lewes, F.C.S., Professor of Chemistry, Royal Naval College, Greenwich.

ACHROMATIC OBJECTIVES. Charles S. Hastings, Ph.D., Professor of Physics, Sheffield Scientific School, Yale University.

ACID AND ALKALI MANUFACTURE. Professor G. Lunge, Zurich. Author of "Sulphuric Acid and Alkali."

ACOUSTICS. Professor J. H. Poynting, D.Sc., F.R.S., Birmingham University.

ACTS OF THE APOSTLES. Rev. J. Vernon Bartlet, Mansfield College, Oxford.

ADAMS, CHARLES FRANCIS. James Ford Rhodes, LL.D. Author of "History of the United States, from the Compromise of 1850."

ADAMS, J. COUCH. Donald Macalister, M.A., M.D., Fellow of St John's College, Cambridge.

ADMIRALTY ADMINISTRATION. *British Empire*, Admiral Sir Vesey Hamilton and John Leyland; *United States*, Rear-Admiral W. T. Sampson, U.S.N.

ADMIRALTY JURISDICTION. The Hon. Sir Walter Phillimore, Bt., Judge of the High Court of Justice.

ADULTERATION. Otto Hehner, Past President of the Society of Public Analysts.

ADVERTISEMENTS. H. R. Haxton.

AERONAUTICS. Octave Chanute, C.E., Hon. Mem. Inst.C.E. Author of "Progress in Flying Machines."

ÆTHER. J. Larmor, D.Sc., Sec. R.S., Fellow of St John's College, Cambridge. Author of "Æther and Matter."

AFFREIGHTMENT. The Hon. Sir Joseph Walton, Judge of the High Court of Justice.

AFGHANISTAN. *Geography and Statistics*, Sir T. H. Holdich, K.C.I.E.; *History*, Sir Alfred Lyall, K.C.B., G.C.I.E.

AFRICA. *Geography*, E. Heawood; *History*, J. Scott Keltie, LL.D.; *Ethnology*, Professor A. H. Keane.

AGRICULTURE. *United Kingdom*, W. Fream; *United States*, Charles W. Dabney, Ph.D., President, University of Tennessee.

AGRICULTURAL MACHINERY. Frank C. Skinner, U.S. Patent Office, Washington.

AINU. Captain F. Brinkley, Tokyo, Japan.

AIR-GUN. Sir George Sydenham Clarke, K.C.M.G., F.R.S., Governor of Victoria.

AIRY. A. A. Rambaut, F.R.S., Radcliffe Observer, Oxford.

ALABAMA. Hon. Hannis Taylor, LL.D., formerly U.S. Minister to Spain. Author of "The Origin and Growth of the English Constitution."

ALASKA. Hon. W. H. Dall, U.S. National Museum, Washington. Author of "Alaska and its Resources."

ALBANIA. J. D. Bourchier, B.A., Athens; *Times* Correspondent in the Balkan States.

ALEXANDER II. and III. Sir Donald Mackenzie Wallace, K.C.I.E., K.C.V.O.

ALGÆ. Professor R. W. Phillips, University College Bangor, North Wales.

ALGEBRA. G. B. Mathews, F.R.S.

ALGEBRAIC FORMS. Major P. A. MacMahon, F.R.S.

ALGERIA and ALGIERS. Paul Loria.

ALLOTMENTS. P. Anderson Graham. Author of "The Rural Exodus."

ALLOYS. Sir W. C. Roberts-Austen, K.C.B., F.R.S., Chemist of the Mint.

ALMA-TADEMA, SIR L. The late W. Cosmo Monkhouse.

ALPS. The Rev. T. G. Bonney, F.R.S., D.Sc., formerly Professor of Geology in University College, London.

ALUMINIUM. E. Ristori, Assoc.M.Inst.C.E.

AMAZON. Colonel G. E. Church.

AMBULANCE. Major J. R. Dodd, M.D., R.A.M.C.

AMERICA (NORTH and SOUTH). Professor W. M. Davis, Harvard University; Professor J. C. Branner, Leland Stanford Junior University; and Professor R. de C. Ward, Harvard University; *Anthropology*, Professor O. T. Mason, A.M., Ph.D., U.S. National Museum, Washington.

AMPHIBIA. G. A. Boulenger, F.R.S., Natural History Museum, South Kensington.

AMPHIOXUS. A. Willey, D.Sc.

AMPTHILL, LORD. The Right Hon. Sir Mountstuart Grant Duff, G.C.S.I., F.R.S.

ANATOMY. *Human*, Professor Alexander Macalister, F.R.S., Cambridge; *of Plants*, A. G. Tansley, University College, London.

ANCHORS. Captain J. W. Dixon, R.N.

ANDAMAN ISLANDS. Lieut.-Colonel Sir R. C. Temple, Bt., C.I.E., Chief Commissioner Andaman and Nicobar Islands.

ANDERSEN, HANS CHRISTIAN. Edmund Gosse, LL.D.

ANDES. Dr F. P. Moreno, Director of the Museum of La Plata.

ANDRASSY, COUNT JULIUS. J. W. Headlam, late Fellow of King's College, Cambridge.

ANGIOSPERMS. Professor I. Bayley Balfour, D.Sc., F.R.S., Edinburgh University.

ANGLICAN COMMUNION. The Rev. Professor W. E. Collins, King's College, London.

ANGLICAN ORDERS. The Rev. W. H. Frere.

ANGLING. "John Bickerdyke."

ANTELOPE. R. Lydekker, F.R.S.

ANTHOZOA. G. C. Bourne, Fellow of New College, Oxford.

ANTHROPOLOGY. Professor E. B. Tylor, F.R.S., Oxford.

ANTHROPOMETRY. Arthur Shadwell, M.D.

ANTI-SEMITISM. Lucien Wolf, late President of the Jewish Historical Society of England.

139138

APOCALYPTIC AND APOCRYPHAL LITERATURE. Rev. Prof. R. H. Charles, Trinity College, Dublin.

APOSTOLICAL CONSTITUTIONS. Rev. Professor W. E. Collins, King's College, London.

APPENDICITIS. Arthur Shadwell, M.D.

AQUARIUM. G. H. Fowler, Ph.D., and Dr Giesbrecht.

AQUEDUCT. E. P. Hill, M.Inst.C.E.

ARABIA. Sir T. H. Holdich, K.C.I.E.

ARACHNIDA. E. Ray Lankester, LL.D., F.R.S., Director of the Natural History Museum, South Kensington.

ARBITRATION. A. Wood Renton, Puisne Judge of Mauritius; *International*, M. Crackanthorpe, K.C.

ARCHÆOLOGY, CLASSICAL. Percy Gardner, Litt.D., Lincoln and Merton Professor of Classical Archæology, Oxford.

ARCHITECTURE. *Modern*, H. H. Statham, Editor of "The Builder"; *Archæological*, R. Phené Spiers, Master of the Architectural School, Royal Academy, London.

ARGON. Lord Rayleigh, D.C.L., F.R.S.

ARGOS. Charles Waldstein, Litt.D., Fellow of King's College, Cambridge.

ARISTIDES, APOLOGY OF. The Rev. J. Armitage Robinson, D.D., Canon of Westminster.

ARIZONA. Professor Wm. P. Blake, A.M., Director of School of Mines, University of Arizona.

ARKANSAS. Hon. Edgar E. Bryant, LL.D., formerly Justice of the Circuit Court of Arkansas.

ARMENIA. Sir C. W. Wilson, R.E., K.C.B.

ARMIES. *British*, Major-General Sir J. F. Maurice, K.C.B.; *British Colonial*, Major Mathew Nathan; *Indian*, Sir J. J. H. Gordon, K.C.B.; *United States*, Lieut.-Col. W. A. Simpson, Asst. Adj.-Gen., U.S.A.; *Italian, Swiss, Russian, and Turkish*, Sir George S. Clarke; *German*, Lieut.-Colonel J. M. Grierson; *French and Austrian*, Lieut.-Colonel E. M. Lloyd.

ARMOUR. The late Capt. C. Orde-Browne.

ARNOLD, MATTHEW. Theodore Watts-Dunton.

ART GALLERIES. Lord Balcarres, M.P.

ARTHROPODA. E. Ray Lankester, LL.D., F.R.S.

ART SALES. W. Roberts.

ART SOCIETIES. A. R. C. Carter.

ART TEACHING, and ARTS AND CRAFTS. Walter Crane, formerly Principal of the Royal College of Art, South Kensington.

ASBJÖRNSEN and MÖE. Edmund Gosse, LL.D.

ASIA. Sir T. H. Holdich, K.C.I.E.

ASIA MINOR. Sir C. W. Wilson, R.E., K.C.B.

ASSAYING. Andrew A. Blair, author of "The Chemical Analysis of Iron," &c.

ASTRONOMY. Professor Simon Newcomb, Ph.D., LL.D., D.Sc., formerly Director U.S. "Nautical Almanac"; Professor of Mathematics and Astronomy, Johns Hopkins University.

ATHENS. J. D. Bourchier.

ATHLETIC SPORTS. *British*, Montague Shearman; *United States*, Walter Camp, author of "Book of College Sports."

ATLANTIC OCEAN. H. N. Dickson.

ATMOSPHERIC ELECTRICITY. Charles Chree, D.Sc., F.R.S., National Physical Laboratory.

AUSTRALIA. Rev. J. Milne Curran, and T. A. Coghlan, Government Statistician, New South Wales.

PREFACE

THE first edition of the *Encyclopædia Britannica* was prepared by "A Society of Gentlemen in Scotland," as the authors are described on the title-page, and the first weekly section was sold in December 1768 by "Colin Macfarquhar, at his printing office in Nicolson Street," Edinburgh. In 1771 the publication was completed in three volumes quarto, containing 2670 pages and 160 copper plates. From this small beginning the *Encyclopædia Britannica* has increased, in size as well as in importance, until the present edition, when completed by the new volumes, to the first of which these words of introduction are prefixed, will include more than 28,000 pages and more than 12,000 plates, maps, and other illustrations. The evolution, during the one hundred and thirty-four intervening years, was gradual. The second edition, containing 8595 pages, was completed in 1784; the third, 14,579 pages, in 1797; the fourth, 16,033 pages, in 1810; the fifth, 16,017 pages, in 1817; the supplement to the fifth edition, 4933 pages, in 1820; the sixth edition, 16,017 pages, in 1823; the seventh, 17,011 pages, in 1842; the eighth, 17,957 pages, in 1861. The first volume of the Ninth Edition was published in 1875, and the last, making a total of 21,572 pages, in 1889; and the continued public recognition of the utility of the *Encyclopædia Britannica* is strikingly shown by the fact that of this Ninth Edition more than forty thousand copies have been purchased in the United Kingdom alone during the past four years. The vitality and authority which the *Encyclopædia Britannica* has maintained through a period of almost a century and a half may be attributed to two conspicuous and distinctive characteristics, inherent in the purpose, and apparent in the execution, of its successive editions. In the first place, the publishers and the successive editors, from the beginning, brought to the undertaking an elevated view of their task. The Scottish origin of the work imparted to its inception a certain sternness of purpose, and the perfecting of the successive editions has been almost a cult, as well as a business. The second characteristic, the collaboration of distinguished contributors, was at once a corollary of the policy of the editors and a result of the reputation which the *Encyclopædia Britannica* so promptly acquired and so firmly retained. The fact has often been cited that in 1812 Dugald Stewart received for one "Philosophical Dissertation," in the supplement to the fifth edition, a sum of £1700, which was then an unprecedented remuneration for such a task, and from that time the cost of obtaining the best work seems never to have given pause to an editor. But no scale of payment, however liberal, could have enlisted the services of all the distinguished men who contributed to these nine editions, if they had not held in high esteem the national library of reference—no longer merely a Scottish enterprise—for which they were invited to write. Sir Walter Scott, Macaulay, Arago, Hazlitt, De Quincey, Professor Playfair, Jeffrey, Charles Kingsley, Ricardo, Dr Hooker, Layard, Baron Bunsen, Sir David Brewster, and Professor Owen were among the contributors to the first eight editions. The contributors to the Ninth Edition numbered more than a thousand, among them so many men of the highest distinction that their quality can only be indicated by the citation of a few such names as those of Professor Huxley, Lord Kelvin, Lord Rayleigh, Sir Archibald Geikie, Professor Max-Müller, Professor Ray Lankester, Sir William Crookes, Sir Robert Ball, Mr Alfred Russel Wallace, Mr Swinburne, and Robert Louis Stevenson. The statement that the last of the new volumes of the *Encyclopædia Britannica* will be published within a year, and that the contributors are a body no less distinguished and proportionately even more numerous, completes this brief summary of the history of the work. It has been the aim of the editors to make the new volumes so complete that no further edition will be required by the present generation, for the new portion of the work, in combination with the existing volumes of the Ninth Edition, forms, for all intents and purposes, a tenth edition.

These new volumes constitute a new, distinctive, and independent library of reference, dealing with modern developments of science, art, literature, history, biography, sociology, industry, commerce, invention, medicine and surgery, although their primary purpose is to supplement, complete, and bring up to date the Ninth Edition. The urgency of complementing that edition was even greater than the date of its publication would indicate. The first four volumes were published in 1875, the remainder appearing at varying intervals until the work was completed in 1889. Roughly speaking, the year 1880 may be regarded as a median date fairly representing the time of production of the average article. As a matter of fact, however, the Ninth Edition gave to the events of the Victorian Era a consideration less minute than that which it accorded to earlier periods of history and earlier developments of the arts and sciences. The intellectual point of view, in 1875, was influenced by scholastic traditions of which the rigour has since undergone considerable modification. It was then the practice to await patiently a future time at which what was called the historical perspective might be attained. It was thought imprudent for the writer to venture upon ice as yet but newly formed. The article upon the History of England, for example, appeared in the eighth volume, published in 1878, and of its 104 pages, 102 are concerned with events prior to the death of George IV., and only two with English history subsequent to 1830. In adopting this policy, the editors of the Ninth Edition acted in accordance with the best opinion of their generation. Since their day opinion has altered; it now seems proper that a work of reference should, as closely as is consistent with the avoidance of hasty judgment, present a full account of the most recent events and the latest phases of progress. The new volumes thus cover a period of time and a field of subject-matter proportionately larger than the period and field which the Ninth Edition added to the scope of the eighth. In selecting the point of departure for each article, as well as in deciding upon the moment at which its subject should be relinquished, the editors have been impelled by the changed conditions of our time to give more space than would have been required if they had been content to regard their task as limited by a period of twenty years, and by the degree of reticence with regard to recent events which was formerly thought to be advisable. Of the sixteen thousand articles in the Ninth Edition, a great number needed no revision, but many others—even among the articles dealing with completed achievements, such as the lives of men long since deceased, and the histories of extinct nations—called for modification as a result of recent research. Yet, if the last twenty years alone were to be displayed to the reader, they would be recognized as marked by a progress absolutely unmatched in any equal period of the world's history.

Sir Archibald Geikie, on the occasion of the banquet held at Christ's College, Cambridge, in 1888, to celebrate the issue of the twenty-fourth volume of the Ninth Edition, expressed a wish that it were possible explicitly to contrast the conditions and prospects of the world at that time with what they had been when the eighth edition was completed in 1861, "to sketch the vast realms of knowledge and of thought that had been conquered, and to enumerate even a few of the great treasures, undreamt of in variety and value, which have been added to the sum of human knowledge." Such an apposition, displaying side by side the state of human knowledge in 1880 and its present state, would yield an even more striking lesson. Within these twenty years—and as we have seen, the period covered by the new volumes is in fact much longer—there have been astounding changes in all departments: political, social, economic, religious, scientific, literary, and artistic. Political frontiers have been altered by wars and conventions; the British Empire has vastly increased in vitality as well as in extent; America, recovered from the shock of her Civil War, has become a world-power as well as an industrial factor of the first importance; Germany, since the Franco-Prussian War, has become another industrial competitor; France has made extraordinary efforts to regain lost ground; and in the Far East, Japan has attained an unforeseen importance. The chief postulates of all branches of inquiry have been revolutionized by the widespread application of the theory of evolution and of new methods of research, while the application of science to the arts has enlarged our vision and led to new inventions in every sphere of life. Preventive medicine and aseptic surgery have come into existence and been matured; literary and artistic production has increased with almost unexampled rapidity, and much of this increase has been wholesome and deserves attention; great men and women have passed away, leaving their lives to the enlightenment of posterity, and new personalities of commanding importance have come to the front.

Containing, as they do, not only an account of this fertile period, but dealing also with many events and developments earlier in the Victorian Era, the new volumes cannot but be of use as a distinct encyclopædia of modern progress, adapted to the wants of readers who desire to confine their reading to modern topics. In order, on the other hand, to estimate the practical utility of the new volumes, if they be regarded as a supplement to the *Encyclopædia Britannica*, attention must be given not only to the inevitable gaps with which the lapse of time has pitted the Ninth Edition, but also to the position which that edition occupies in public esteem. In the United Kingdom alone more than fifty thousand persons possess the Ninth Edition and regard it as the most authoritative work of reference. In the United States more than four hundred thousand copies have been purchased. There are, therefore, in all parts of the English-speaking world, a vast body of men who habitually use the work and who await the appearance of a complement to its contents. They form the half-million readers whose requirements the editors have had primarily to consider. The endeavour to meet these requirements has been made at a particularly happy moment, for, in nearly all civilized countries, a census was completed just in time to enable the editors and contributors to avail themselves of the latest official statistics. It is not simply in respect of its statistical information that a census yields important material. It affords a large body of fresh facts with regard to public health, commerce, agriculture, and manufacture, the spread of education, and the comparative vitality of various nations, so that articles of many different sorts are far richer and fuller than they could otherwise have been. There is, indeed, no publication other than these new volumes in which the results of this world-wide census are similarly comprised.

To the twenty-four volumes of text in the Ninth Edition of the *Encyclopædia Britannica* there will now be added eleven further volumes containing 10,000 articles by 1000 contributors, 2500 new maps, plates, portraits, and other illustrations; in all about 7000 new pages, the volumes being of the same size as those of the Ninth Edition. The preparation of the new volumes was begun early in 1899, but the first year's work was largely devoted to fixing the scope and plan of the work, determining the subjects to be treated, selecting the departmental editors, to the selection by them of the contributors (a choice which could judiciously be made only by men of special technical knowledge), and to the discussions which necessarily preceded the actual task of writing. In order that the various contributions, especially those in which statistics play an important part, or in which new inventions or discoveries are described, should be checked and corrected in the light of the most recent research, all the articles have been carried in type, subject to revision by editors and contributors, and will thus be found to contain information available only a few weeks before they issue from the press. So great is the number of subjects treated in the new volumes, and so thorough their treatment, that only the most zealous goodwill on the part of the contributors has made it possible to keep the new matter within eleven volumes. This limitation was the more difficult, or from another point of view the size of the supplement was the more inevitable, for another reason. In the earlier history of the *Encyclopædia Britannica*, we find that biographies of any sort were barely tolerated. In 1776 the third Duke of Buccleuch, who was greatly interested in the project of the second edition, had much difficulty in persuading the editors to include biographical articles, which they deemed "inconsistent with the purpose of a dictionary of arts and sciences." In the case of the new volumes it has been thought necessary, in order to bring the biographical section up to date and to make it as comprehensive as other sections, to include lives of certain living men and women. The policy of the editors in this particular was to select for the most part the lives of those whose positions had become so fixed that, whatever promise of future achievement their continued vigour might give, there was no reason to believe that the general character and purpose of their work would materially change. Among the younger generation, biographies are included of reigning sovereigns or heads of states, and of some few others whose names are already of commanding interest.

A noteworthy feature of the new volumes will be the new and comprehensive index to the completed work, covering under one alphabetization the Ninth Edition and the new volumes. It will contain more than 600,000 entries, and will not only be exceedingly minute in its analysis, displaying the latest development of the time-saving art of precise indexing, but will also be by far the most complete index to the general sum of human knowledge which has ever been compiled. An index thus constructed on modern lines will greatly facilitate the use of such a work as this, for its possessor will enjoy the advantages, without suffering the disadvantages, which mark a work of reference consisting of general treatises rather than of brief and fragmentary articles treating, after the manner of a dictionary, each subdivision of a subject under a separate heading. This dictionary system of treatment gives a far less readable result, and its practical convenience is no greater than that which the new volumes will offer with the aid of their elaborate index.

Other considerations which affected the size of the supplement were the need for new maps, called for by recent political changes and geographical discoveries, and also the necessity for copious illustration. The Ninth Edition was more amply illustrated than any former work of reference had been, and since its time the utility of informative illustration, as distinguished from mere pictures, has become more and more generally recognized. A picture of a machine, occupying a few square inches of space, conveys a clearer impression than a whole page of description. The new volumes are therefore even more copiously illustrated than were those of the Ninth Edition, and the 2500 separate drawings which were made will, it is believed, fully justify the great care which has been expended upon them. The portraits and reproductions of pictures which accompany the biographies of living celebrities have in important instances been chosen for this purpose by the persons themselves, and the engravings have all been executed specially for the work. Every effort has been made to conserve in the new matter the high standard of the Ninth Edition, although the articles are conceived in a spirit more modern than that which obtained a generation ago. The present demand for practical details, for the industrial as well as the theoretical point of view in treating scientific developments—a natural result of the fact that new classes of readers have been stimulated to practical research by the spread of education—is another factor which contributed to the number and variety of the articles. Men who are engaged, if not literally in the manual processes of manufacture, at any rate in the immediate supervision of these processes, form a section of the reading public peculiarly exacting in their requirements. The great keenness of competition between English and foreign manufacturers furthermore makes it essential that financial, commercial, industrial, and scientific topics should not be approached from an insular and restricted point of view.

With this and many other considerations in mind, the selection of the contributors to the new volumes was a task of great delicacy. The first step was to choose the departmental editors by whom the individual contributors should in turn be nominated, and in both respects the editors believe the selections have been remarkably successful. A list of departmental editors and of contributors will be found in another part of the work, and it will be perceived that German, French, Dutch, Italian, Spanish, Russian, and Scandinavian writers have done much to round off the comprehensiveness of these new volumes, and to bring to a wider field of examination the same spirit of accurate scrutiny which characterized the Ninth Edition. It may be doubted whether in any previous work of reference the advantages to be gained from the cosmopolitan character of the staff of contributors have been so fully attained. Absolutely no discrimination was made between British and foreign writers, contributions having been invited from the men believed to be best qualified to write upon each of the subjects to be treated, and in respect especially of American writers the result has greatly added to the comprehensiveness of the work. Certain fields of applied science and industrial development have of late years owed so much to American initiative, and the subjects in regard to which it was desirable to enlist the co-operation of American writers consequently proved to be so numerous, that an editorial branch office was opened in New York. The names of the American departmental editors and contributors speak for themselves, and for the purpose of this preface it is sufficient to say that, while *Le Figaro* described the Ninth Edition as "*Un monument littéraire auquel l'Europe savante tout entière a collaboré*," these supplementary volumes are the product of the New World as well as of the Old.

It has already been observed that readers in the United States form a considerable proportion of the public to which these volumes may be expected to appeal, but it should be noted that the care with which American and Colonial subjects are treated would have been as sedulous if the supplement had been intended for readers in the United Kingdom only. The world beyond our own islands, and especially the English-speaking part of it, has become more intimately associated with our life and thought than it was twenty years ago. Cargoes of wool from Australia, and of cotton from America, are no longer the only enrichment we receive from the descendants of the British who betook themselves to fresh fields of enterprise. They send us new ideas and new inventions, and the fruit of their activities becomes indistinguishable from other portions of the common heritage of the race.

In allotting subjects to the various British and foreign writers whose co-operation was invited, the editors were guided solely by the desire to procure the best possible treatises, without regard merely to the measure of reputation enjoyed by individuals, and yet by this process they have associated with the work a body of men whose names will readily be recognized by the general reader. If the collaboration of eminent men can ensure success, an examination of the List of Contributors to these volumes will show that the editors have been greatly favoured. The natural impulse, when contributors are to be chosen, is to enlist the assistance of ready writers and trust to their versatility. But an authoritative work of reference cannot be created by so hazardous a method. Not only men accustomed to literary activity, but those to whom verbal expression is a mere incident of other activities—sailors and soldiers, men busied in commerce and finance, leaders in all the different divisions of life—must bring each his special knowledge to his special subject. That was the policy adopted by the editors of the Ninth Edition, and their example has been followed in the present undertaking.

The editors desire in this connexion to express their great obligation to the departmental editors, whose expert knowledge has been of incalculable service in suggesting the names of the writers best qualified to treat special subjects, and in advising the editors with respect to technical articles. A list of these departmental editors will be found at the beginning of this volume. The editors are also indebted to other eminent authorities for advice with regard to larger aspects of the task. They have not hesitated, in the course of an undertaking so important from every point of view, to ask personal counsel from those whose rank or official position precluded a direct association with the work, and in every instance their requests have met with the fullest acquiescence. More detailed acknowledgments of the editors' many obligations will be found in a note forming part of a later volume.

The practice of identifying the more important articles with their authors by means of initials has been followed in these new volumes to an even greater extent than in the Ninth Edition, although it has not seemed desirable for living writers to sign the biographies of living persons. In a few cases important articles are deliberately left unsigned, for anonymity was necessitated by the fact that only on that condition could the editors induce certain highly-placed writers to undertake subjects which they had made peculiarly their own, and yet could not treat with the detachment which is essential to objective discussion if their personalities were formally associated with what they said. In enlisting the writers of both the signed and the unsigned articles, the editors had to overcome many reluctances, due often to the difficulty in which a new writer is placed when invited to complete another man's work. The editors fully recognize that in this respect, as in others, their labours in the matter of securing the best writers have been lightened by the honour in which the *Encyclopædia Britannica* is held. Unchallenged throughout the changes of more than a century, that work stands as the classical embodiment of the highest scholarship and research. Contributors, as well as editors, are proud to associate their efforts with the traditions of an enterprise which confers some ray of its lustre upon the least among its servants.

THE EDITORS.

LONDON, *May* 1902.

ENCYCLOPÆDIA BRITANNICA

NEW VOLUMES.

AACHEN—AARHUS

Aachen, the German name for *Aix-la-Chapelle* (*q.v.*).

Aalborg, capital of county Aalborg, Denmark, on the S. side of Liimfjord, 87 miles by rail N. from Aarhus, a growing industrial and commercial centre. In 1899, 1532 vessels of 250,745 tons entered the port, and 1599 of 245,681 tons cleared. The iron bridge connecting Aalborg with Nörre Sundby (pop. 3000) on the N. side of the fjord, 1250 ft. long, is one of the finest pieces of engineering in the kingdom. Population, 14,152 (1880); 19,503 (1890); 31,462 (1901).

Aalesund, a seaport town of Norway, situated on a ring of islands surrounding the harbour, co. Romsdal, on the W. coast, 145 miles N. by E. from Bergen. Founded in 1824, it is the principal shipping-place of Söndmöre, and one of the chief stations of the herring fishery. A little to the south of the town are the ruins of the reputed castle of Gangu Hrolf, the founder, in the 9th century, of the dynasty of the dukes of Normandy. Population, 5603 (1875); 8406 (1891); 11,672 (1901).

Aarau, the capital of the canton of Aargau in Switzerland, on the Aar, about 50 miles by rail from Berne, and 31 miles from Zürich. In the parliament house there is some good painted glass of the 16th century from the neighbouring Benedictine abbey of Muri, suppressed in 1841. Aarau was the residence of Heinrich Zschokke (born 1771, died 1848), the well-known Swiss novelist and historian, to whose memory a bronze statue has been recently erected in the town. Population, 6809 (1888); 7824 (1900).

Aargau, a Swiss canton, bounded on the N. by the Rhine, on the E. by Zürich and Zug, on the S. by Lucerne, and on the W. by Basel, Solothurn, and Berne. Its total area is 542 square miles. Of this 517·9 square miles are classed as "productive," forests covering 169 square miles, and vineyards 8·2 square miles. The population was 198,718 in 1870; 198,357 in 1880; 193,580 in 1888; and 206,460 in 1900, being 381 to each square mile. The population is almost exclusively German-speaking; for in 1900 there were but 826 French-speaking, and 2468 Italian-speaking inhabitants. In 1888 there were 85,835 Romanists, 106,351 Protestants, 1051 Jews; in 1900, 91,047 Romanists, 114,218 Protestants, 1010 Jews. The capital is Aarau, the only other towns in the canton which in 1888 had over 3000 inhabitants being Baden, Zofingen (4450), and Reinach (3130). The cantonal constitution dates from 1885. The legislature consists of members elected in the proportion of one to every 1100 (or fraction over 550) inhabitants. The "obligatory referendum" exists in the case of all laws, while 5000 citizens have the right of "initiative" in proposing bills or alterations in the cantonal constitution. The canton sends ten members to the Federal National Assembly, being one for every 20,000, or fraction over 10,000 inhabitants. In 1897 the state revenue was 3,260,156 francs, and the state expenditure 3,064,181 francs, but both in 1898 and in 1899 there was a deficit, while another of 98,600 francs was in the budget of 1900. In 1897 the public debt was 2,430,000 francs, while the productive state property amounted to 19,317,644 francs. There are many old historical castles in Aargau, such as Habsburg, Lenzburg, Wildegg, &c. In 1841 Aargau, under the influence of Augustine Keller, suppressed the eight monasteries (of which the most important were Muri and Wettingen) within its territory, this violent act ultimately leading up to the "Sonderbund" war in Switzerland in 1847.

See *Argovia* (published by the Cantonal Historical Society), Aarau, from 1860.—BRONNER. *Der Kanton Aargau.* 2 vols. St Gall and Bern, 1844.—MERZ, *Die Rechtsquellen d. Kant. Aargau*, 2 vols. as yet. Aarau, 1898 and 1900.—MULLER. *Der Aargau.* 2 vols. Zürich, 1870.

Aarhus, a seaport and bishop's see of Denmark, co. Aarhus, on the E. coast of Jutland, 68 miles by rail N. by E. from Fredericia; the second largest town of the kingdom and the principal port of Jutland. There are two new churches—St Paul's (1885-86) and a Roman

Catholic church (1878-81)—a library (1899), and a theatre (1899). A new harbour basin was made in 1883-90. In 1899 the port was entered by 2711 vessels of 476,439 tons, and cleared by 2710 of 476,380 tons; exports, chiefly agricultural produce (bacon, butter, eggs), coal (162,350 tons), iron, and manure. Pop. 24,831 (1880); 33,306 (1890); 43,000 (official estimate, 1898).

Aasen, Ivar (1813-1896), Norwegian philologist and lexicographer, was born at Aasen i Örsten, in Sondmore, Norway, on the 5th of August 1813. His father, a small peasant-farmer named Ivar Jonsson, died in 1826. He was brought up to farmwork, but he assiduously cultivated all his leisure in reading, and when he was eighteen he opened an elementary school in his native parish. In 1833 he entered the household of H. C. Thoresen, the husband of the eminent writer Magdalene Thoresen, in Hero, and here he picked up the elements of Latin. Gradually, and by dint of infinite patience and concentration, the young peasant became master of many languages, and began the scientific study of their structure. About 1841 he had freed himself from all the burden of manual labour, and could occupy his thoughts with the dialect of his native district, the Sondmöre; his first publication was a small collection of folk-songs in the Söndmore language, 1843. His remarkable abilities now attracted general attention, and he was helped to continue his studies undisturbed. His *Grammar of the Norwegian Dialects*, 1848, was the result of much labour, and of journeys taken to every part of the country. Aasen's famous *Dictionary of the Norwegian Dialects* appeared in its original form in 1850, and from this publication dates all the wide cultivation of the popular language in Norwegian, since Aasen really did no less than construct, out of the different materials at his disposal, a popular language or definite *folke-maal* for Norway. With certain modifications, the most important of which were introduced later by Aasen himself, this artificial language is that which has been adopted ever since by those who write in dialect, and which fanatics to-day (1901) are once more endeavouring to foist upon Norway as her official language in the place of Dano-Norwegian. Aasen composed poems and plays in the composite dialect to show how it should be used; one of these dramas, *The Heir* (1855), was frequently acted, and may be considered as the pioneer of all the abundant dialect-literature of the last half-century, from Vinje down to Garborg. Aasen continued to enlarge and improve his grammars and his dictionary. He lived very quietly in lodgings in Christiania, surrounded by his books and shrinking from publicity, but his name grew into wide political favour as his ideas about the language of the peasants became more and more the watchword of the popular party. Quite early in his career, 1842, he had begun to receive a stipend to enable him to give his entire attention to his philological investigations; and the Storthing—conscious of the national importance of his work—treated him in this respect with more and more generosity as he advanced in years. He continued his investigations to the last, but it may be said that, after the 1873 edition of his *Dictionary*, he added but little to his stores. Ivar Aasen holds perhaps an isolated place in literary history as the one man who has invented, or at least selected and constructed, a language which has pleased so many thousands of his countrymen that they have accepted it for their schools, their sermons, and their songs. He died in Christiania on the 23rd of September 1896, and was buried with public honours.

(E. G.)

Abádeh, a small walled town in the province of Fars in Persia, situated at an elevation of 6200 feet in a fertile plain on the high road between Isfahan and Shiraz, 140 miles from the former and 170 miles from the latter place. It has a population of about 4000, is the chief place of a district with the same name, has a telegraph and post office, and is famed for its beautifully-carved sherbet spoons and boxes, which are made from the wood of pear and box-trees.

Abai, lake. See Abyssinia.

Abai, river. See Abyssinia.

Abakan, Abakansk. See Minusinsk.

Abánah, or Amanah (R.V. *Abána*, classical *Chrysorrhoas*, modern *Baradá*), one of the "rivers of Damascus," which rises in the heart of Anti-Lebanon. As the river escapes from the mountains, through a narrow gorge, its waters spread out fan-like, in canals or "rivers," to irrigate the plain and supply Damascus. The name of one "river," Nahr Bániás, retains a trace of Abánah; and, in the Arabic translation of O.T., that of another, Nahr Taúra, takes the place of Pharpar, which is identified by some authorities with the Nahr el-'Awaj.

Abattoir. See Slaughter-houses.

Abbadie, Antoine Thomson d' (1810-1897), and **Arnaud Michel d'** (1815-1893), two brothers notable for their travels in Abyssinia during the first half of the 19th century. They were both born in Dublin, of a French father and an Irish mother, the former in 1810 and the latter in 1815. The parents removed to France in 1818, and there the brothers received a careful scientific education. In 1835 the French Academy sent Antoine on a scientific mission to Brazil, the results of which were published at a later date (1873) under the title of *Observations relatives à la physique du globe faites au Brésil et en Éthiopie*. The younger spent some time in Algeria before, in 1837, the two brothers started for Abyssinia, landing at Massawa in February 1838. They visited various parts of Abyssinia, sometimes together, and sometimes separately; not only the fairly well-known northern and central districts, but also the then little-known districts of Ennarea and Kaffa. They met with many difficulties and many adventures, and became involved in political intrigues, Antoine especially exercising such influence as he possessed in favour of France and the Roman Catholic missionaries. After collecting much valuable information concerning the geography, geology, archæology, and natural history of Abyssinia, the brothers returned to France in 1848 and began to prepare their materials for publication. The younger brother, Arnaud, paid another visit to Abyssinia in 1853. The more distinguished brother, Antoine, became involved in various controversies relating both to his geographical results and his political intrigues. He was especially attacked by Dr Beke, who impugned his veracity, especially with reference to the journey to Kaffa. But time and the investigations of subsequent explorers have shown that Abbadie was quite trustworthy. The topographical results of his explorations were published in Paris in 1860-73 in *Géodésie d'Éthiopie*, full of the most valuable information and illustrated by ten maps. Of the *Géographie de l'Éthiopie* (Paris, 1890) only one volume has been published. In *Un catalogue raisonné de manuscrits Éthiopiens* (Paris, 1859) is a description of 234 Ethiopian manuscripts collected by Antoine. He also compiled various vocabularies, including a *Dictionnaire de la langue amarinna* (Paris, 1881), and prepared an edition of the *Pastor of Hermes*, with the Latin version, in 1860. He published numerous papers dealing with the geography of Abyssinia, Ethiopian coins, and ancient inscriptions. Under the title of *Reconnaissances Magnétiques*, he published in 1890 an account of the magnetic observations made by him in the course of several journeys to the Red Sea and the Levant. The general account of the travels of the two brothers was published by Arnaud in 1868 under the title of *Douze ans dans la Haute-Éthiopie.* Both brothers received the grand medal of the Paris Geographical Society in 1850. Antoine was a Knight of the Legion of Honour and a member of the Academy of Sciences. He died in 1897, and, subject to the life-interest of his wife, bequeathed an estate in the Pyrenees, yielding 40,000 francs a year, to the Academy of Sciences, on condition of its producing within fifty years a catalogue of half-a-million stars. His brother Arnaud died in 1893. (J. S. K.)

Abbas II., KHEDIVE OF EGYPT.—Abbas Helmi Pasha, born in 1874, succeeded his father, Tewfik Pasha, as Khedive of Egypt in 1892. He was barely of age according to the Turkish law, which fixes majority at eighteen in cases of succession to the throne. He came straight from his college at Vienna to Cairo, where his accession was celebrated with great pomp, and the firman from the Sultan confirming him in all the powers and privileges and territorial rights which his father enjoyed was read from the steps of the Palace in Abdin Square. He is the great-great-grandson of Mehemet Ali, the founder of the present Egyptian dynasty. When quite a boy he visited England, and did not see it again until he paid a viceregal visit in 1899. He had an English tutor for some time in Cairo, and then went to school in Lausanne, and from there he passed on to the Theresianum in Vienna, whence he was called to the throne by the premature and sudden death of his father. Turkish is his mother tongue, but he talks Arabic with great fluency and speaks English, French, and German very well. For some time he did not co-operate very cordially with Great Britain. He was young and eager to exercise his new power. His throne and life had not been saved for him by the British, as was the case with his father. He was surrounded by intriguers who were playing a game of their own, and for some time he appeared almost disposed to be as reactionary as his great-uncle, Abbas I. But in process of time he learnt to understand the importance of British counsels. During his visit to England in 1899 he frankly acknowledged the great good the British had done in Egypt, and declared himself ready to follow their advice and to co-operate with the British officials administering Egyptian affairs. The establishment of a sound system of native justice, the great remission of taxation, the reconquest of the Soudan, the inauguration of the stupendous irrigation works at Assouan, the increase of cheap, sound education, have each received his approval and all the assistance he could give. The waters of oblivion cover the quarrel, based on unfounded accusations, which he chose to have with Sir H. (afterwards Lord) Kitchener when that general was Commander-in-Chief of the Egyptian army; and no one more than the Khedive rejoiced over the battle of Omdurman. Agriculture and all the interests of farming are dearer to the heart of the Khedive than statecraft. At Koubah, near Cairo, he has a farm of cattle and horses that would do credit to any agricultural show in England, and at Montaza, near Alexandria, he has a similar establishment. He rides well, drives well, rises early, neither smokes nor drinks. The Vice-Reine or Khediviah, his wife, has given him first a daughter and then a son, and the latter is the heir to the throne.

Abbas-Tuman, a spa situated in Caucasia, government of Tiflis, on a mountain road of Akhaltsykh, 50 miles from the Borzhom railway station, very picturesquely situated at an altitude of 4413 feet. It has a high-level astronomical observatory.

Abbazia, a popular summer and winter resort on the Gulf of Fiume, in the Austrian province of Istria, in a sheltered situation at the foot of the Monte Maggiore. The average temperature is 77° in summer and 50° in winter. The old abbey, from which the place derives its name, has been converted into a villa. Local population (1890), 1192; (1900), 2343.

Abbeville, chief town of arrondissement, in the department of Somme, France, 28 miles N.W. of Amiens, on railway from Paris to Boulogne and Calais. It is a very important industrial centre; and, in addition to its old-established textile productions, hemp-spinning, sugar manufacture, and ship-building are among the industries, and there is active commerce in grain and textile fabrics. Population (1881), 18,065; (1891), 18,022; (1896), 19,669.

Abbiategrasso, a town of Lombardy, prov. Milan, Italy, 17 miles S.W. from Milan on the Bereguardo Canal. It is the seat of one of the new commercial courts of arbitration of the prov. of Milan. Population, 7025 (1881); 12,184 (1901).

Abbot, Ezra (1819-1884), American biblical scholar, was born in Jackson, Maine, 28th April 1819. He graduated at Bowdoin College in 1840; was appointed assistant librarian of Harvard University in 1856; and in 1872 became professor of New Testament criticism and interpretation in the divinity school of the same institution. For some time previously his studies had been chiefly in Oriental languages and the textual criticism of the New Testament, though his work as a bibliographer had shown such results as the exhaustive list of writings (5300 in all) on the doctrine of the Future Life, appended to W. R. Alger's work on that subject. His publications, though always of the most thorough and most scholarly character, were to a large extent dispersed in the pages of reviews, dictionaries, concordances, texts edited by others, Unitarian controversial treatises, &c.; but he took a more conspicuous and more personal part in the preparation (with the Baptist scholar Horatio B. Hackett) of the enlarged American edition of Dr (afterwards Sir) William Smith's *Dictionary of the Bible* (1867-70), and was an efficient member of the American revision committee employed in connexion with the Revised Version (1881-85) of the King James Bible. His principal single production, representing his scholarly method and conservative conclusions, was *The Authorship of the Fourth Gospel; External Evidences* (1880; second edition, with other essays, 1888), deemed by Dr Philip Schaff and other scholars the ablest defence, based on external evidence, of the Johannean authorship. Abbot, though a layman, received the degree of D.D. from Harvard in 1872. He died in Cambridge, Massachusetts, 21st March 1884.

Abbott, Edwin Abbott, D.D. (1838——), English theological writer, educationalist, and scholar, formerly headmaster of the City of London school, son of the late Edwin Abbott, headmaster of the philological school, Marylebone, was born 20th December 1838. He was educated at the City of London school and at Cambridge, where he took the highest honours in the classical, mathematical, and theological triposes (senior classic, Chancellor's medallist, and senior optime, 1861; 1st cl. Theology, 1862), and became fellow of his College (St John's). In 1862 he was ordained, taking priest's orders in 1863. After holding masterships at King Edward's School, Birmingham, and at Clifton College, he succeeded

Dr Mortimer as headmaster of the City of London school in 1865 at the unusually early age of twenty-six, and more than maintained the high character which the school had obtained under his predecessor. He retired in 1889, and has since devoted himself to literary and theological pursuits. Dr Abbott's liberal inclinations in theology have been prominent both in his educational views and in his books. He has written several works on grammar, both English and Latin, and is the author of a life of Bacon (1885) and of an investigation of his relations with Essex (1877). Of his theological writings (which include some that have been published anonymously) the best known are his religious romances—*Philochristus* (1878) and *Onesimus* (1882), *The Kernel and the Husk* (1886), *Philomythus* (1891), his criticism on *Cardinal Newman as an Anglican* (1892), and his article on "The Gospels" in the ninth edition of the *Encyclopædia Britannica*.

Abbott, Jacob (1803-1879), a popular American writer of books for the young, was born in Hallowell, Maine, on the 14th of November 1803. He graduated at Bowdoin College at the age of seventeen; studied at Andover Theological Seminary; became a congregational minister; was for a brief period professor of mathematics and physics in Amherst College; and afterwards taught in schools at New York and Farmington, Maine, though devoting himself chiefly to the writing of juvenile stories, brief histories and biographies, or religious books for the general reader, together with a few works in popular science. His "Rollo Books"—*Rollo at Work*, *Rollo at Play*, *Rollo in Europe*, &c.—are the best known of his writings, having as their chief characters a representative boy and his associates. In them Abbott did for one or two generations of young American readers a service not unlike that performed earlier, in England and America, by the authors of *Evenings at Home*, *Sandford and Merton*, and the *Parent's Assistant*. Of his other writings—he produced more than two hundred volumes in all—the best are the *Franconia Stories*, a long series of biographical histories (with his brother John S. C. Abbott), and *The Young Christian*. Their merits are interestingness and clearness of statement; their faults a prevalent didacticism, and, in the histories, a superficial treatment of authorities, perhaps necessitated by the great range of ground covered by the author. He died at Farmington on the 31st of October 1879.

Abbott, John Stevens Cabot (1805-1877), American writer, was born in Brunswick, Maine, 18th September 1805. He was a brother of Jacob Abbott, and was associated with him in the preparation of his series of brief historical biographies, but is best known as the author of a partisan and unscholarly, but widely popular and very readable, *History of Napoleon Bonaparte* (1855), in which the various elements and episodes in Napoleon's career are treated with some skill in arrangement, but with unfailing adulation. Like his brother, Dr Abbott was a graduate of Bowdoin College, a congregational minister, a teacher, and a voluminous writer of books on Christian ethics, &c., though he never attempted the fictitious story for children. He died at Fair Haven, Conn., on the 17th of June 1877.

Abbottabad, a town of British India, 4166 feet above sea-level, 63 miles from Rawal Pindi, the headquarters of the Hazara district in the Punjab, called after its founder, Sir James Abbott, who settled this wild district after the annexation of the Punjab. It is an important military cantonment, with two native infantry regiments and a mountain battery; and the headquarters of the Punjab frontier force. Nearest railway station, Hasan Abdul (44 miles). Population, about 10,000. Municipal income (1896-97), Rs.13,588.

Abd-el-Kader (1807-1883), Emir of Mascara, the most prominent representative of Mussulman resistance to French conquest in Algeria, was born at Mascara, an Arab town between 40 and 50 miles south-east of Oran, in 1807. His family was of princely rank, and he received the best education attainable, especially in Mahommedan divinity and philosophy. Two incidents of his youth had great influence upon his career,—his pilgrimage to Mecca, which stimulated his natural tendency to religious enthusiasm, and a visit to Egypt, where the reforms of Mehemet Ali opened his eyes to the importance of European culture. He was thus doubly prepared for the part he was called upon to perform on the French conquest of Algiers in 1830. Becoming emir of Mascara by the renunciation of his father, he carried on war with the French until 1834, when peace was concluded; but Abd-el-Kader's endeavours to reorganize his principality on a European model excited the jealousy of the French, and war again broke out in the following year. Mascara was taken in October 1835, but the contest on the whole was unfavourable to the French, and peace was eventually made in 1837, on terms highly honourable to Abd-el-Kader. He nevertheless imprudently recommenced the struggle in 1839, and although his capital was again taken in 1841, protracted it until 1844, when he was compelled to seek refuge in Morocco. The French under Marshal Bugeaud crossed the frontier, and in June entirely defeated the Moorish army at Isly, thus virtually ending the Arab revolt. The sultan, though compelled to make peace, continued to give Abd-el-Kader an asylum as long as possible; but early in 1847 the latter re-entered Algeria, and was made prisoner. In violation, as alleged, of the terms of surrender, he was detained a captive in France until 1852, when he was released by Louis Napoleon. He resided successively at Broussa and at Damascus, where in 1860 he rendered such service in repressing an outbreak against the Christians that he received the insignia of the Legion of Honour. In his latter years he devoted himself anew to theology and philosophy, and composed a philosophical treatise which has been translated into French. He died at Damascus 26th May 1883. Abd-el-Kader was an example of all the bright, and few or none of the less prepossessing, traits of the Arab national character. (R. G.)

Abdul-Aziz, Sultan of Turkey (1830-1876), the second son of the great Turkish reformer Sultan Mahmoud, was born 9th February 1830. During the reign of his brother Abdul-Medjid he lived in complete retirement, but upon his accession to the throne (25th June 1861) he manifested a reforming spirit and a disposition to economize in personal expenses, and to bring the administration into harmony with the ideas of European culture. Unfortunately, his extravagant outlay on the army greatly overbalanced the economies effected elsewhere, and years of ruinous loan-raising culminated in national bankruptcy in 1875. Before this event, the sultan's mind had been almost entirely given to a project for securing the succession to his son Izeddin, to the prejudice of his nephew Murad, and in pursuit of this object he had thrown himself into the arms of Russia. Financial disaster combined with Russian preponderance rendered his government intolerable; a movement instigated by the principal pashas compelled his abdication on 30th May 1876, and on 4th June he was stated to have committed suicide. Abdul-Aziz was a violent and obstinate man, of great and not always ill-directed energy, but of narrow intellect, and was probably not entirely sane during the last years of his life.

Abdul Aziz, Sultan of Morocco, is the son of Sultan Mulai-Hassan. He was born about 1881, and succeeded to the throne on the death of his father, 7th June 1894, being proclaimed sultan in the Sherifian Camp on the 11th of the same month. In the following October he received the British mission, under Sir Ernest Satow, with the utmost cordiality at Fez, and a convention was signed in April 1895. The sultan has proved constant in his friendship to Great Britain, and welcomed Sir Arthur Nicholson, the British minister, in 1896. In the following year he made a vigorous campaign against the Riffians and others of his disaffected subjects, and overthrew them completely at Tadla, in October 1897.

Abdul-Hamid II., Sultan of Turkey, is the second son of Sultan Abdul-Medjid, who reigned from 1839 to 1861. He was born 22nd September 1842, and succeeded on 31st August 1876, on the deposition of his brother Murad on the ground of insanity. His position at the time was very difficult, and he feigned sympathy at first with the policy of reform advocated by progressive officials such as Midhat Pasha. The revolt of the Christian subjects of the Porte in European Turkey, and the barbarous methods adopted to quench Bulgarian disaffection, equally played into the hands of Russia; and though, during the Russo-Turkish war (1877-78), the military virtues of the Turkish soldier and the gallant defence of Plevna restored a large measure of sympathy to Turkey, the treaties of San Stefano and of Berlin marked a further stage in the dismemberment of the Ottoman empire. As soon as the war was over, Abdul Hamid began to apply himself, with equal dexterity and persistency, to two great objects, viz., the substitution of his own personal authority for that of the great bureaucracy which had ruled Turkey under his immediate predecessors from the Sublime Porte, and the extension of his influence as spiritual sovereign or Kalif in compensation for the loss of temporal power inflicted upon the sultanate. To establish his autocracy he did not shrink from sacrificing all the ablest men in his empire. His external policy was scarcely less successful and less unscrupulous. His dexterous diplomacy played off one great Power against another, and enabled him even to escape the storm which threatened at one moment to overwhelm him, when public opinion in Europe, and especially in England, realized the horror of the Armenian massacres in 1896. Russia secretly, and Germany openly, discountenanced Lord Salisbury's efforts to secure the united action of Europe, and the Cretan insurrection soon diverted the attention of diplomacy to another quarter. The successful war with Greece in 1897 did much to revive Turkish military prestige; and the practical loss of Crete, although evincing the decay into which the Turkish navy had been allowed to fall, rather increased than diminished the strength of the empire. Perhaps the most important feature in Abdul-Hamid's later policy has been the disposition shown to rely upon Germany, and to grant that Power special privileges in Asia Minor.

For a fuller account of his reign, see Turkey, Armenia, Crete, Bulgaria, &c.

Abdullah Khalifa (Sayed Abdullah Ibu-Sayed Mohammed), (1846-1899), successor of the Mahdi Mohammed Ahmed, was born in 1846 in the south-western portion of Darfur, and belonged to the Taaisha section of the Baggara or cattle-owning Arabs. His father, Mohammed et Tahis, had determined to emigrate to Mecca with his family; but the unsettled state of the country long prevented him, and he died in Africa after advising his eldest son, Abdullah, to take refuge with some religious sheikh on the Nile, and to proceed to Mecca on a favourable opportunity. Abdullah, who had already had much connexion with slave-hunters, and had fought against the Egyptian conquest of Darfur, departed for the Nile valley with this purpose; but, hearing on the way of the disputes of Mohammed Ahmed, who had not yet claimed a sacred character, with the Egyptian officials, he went to him in spite of great difficulties, and, according to his own statement, at once recognized in him the Mahdi ("Director") divinely appointed to regenerate Islam in the latter days. His advice to Mohammed to stir up revolt in Darfur and Kordofan being justified by the result, he became his most trusted counsellor, and was soon declared khalifa or vicegerent of the Mahdi, all of whose acts were to be regarded as the Mahdi's own. The Mahdi on his deathbed (1885) solemnly named him his successor; and for many years Abdullah, though to European ideas a monster of cruelty, injustice, and hypocrisy, ruled successfully over the Sudan, with little opposition from within, and extending his sway over neighbouring districts. Khartum was deserted by his orders, and Omdurman, at first intended as a temporary camp, was made his capital. At length the progress of Sir H. (afterwards Lord) Kitchener's expedition compelled him to give battle to the Anglo-Egyptian forces near Omdurman, where on 2nd September 1898 his army, fighting with desperate courage, was almost annihilated. He fled to the north, but want of provisions in the following year compelled him to venture too near the army of Sir Francis Wingate, by whom, at the end of November 1899, he was overtaken and slain at the battle of Om Debrihat. He met death with great fortitude, refusing to fly, and his principal emirs voluntarily perished with him. (R. G.)

Abdurrahman Khan, Amir of Kabul (Afghanistan), (*circa* 1844-1901), was the son of Afzul Khan, who was the eldest son of Dost Mahommed Khan, the famous Amir, by whose success in war the Barakzaie family established their dynasty in the rulership of Afghanistan. Before his death at Herat, 9th June 1863, Dost Mahommed had nominated as his successor Sher Ali, his third son, passing over the two elder brothers, Afzul Khan and Azim Khan; and at first the new Amir was quietly recognized. But after a few months Afzul Khan raised an insurrection in the northern province, between the Hindu Kūsh mountains and the Oxus, where he had been governing when his father died; and then began a fierce contest for power among the sons of Dost Mahommed, which lasted for nearly five years. In this war, which resembles in character, and in its striking vicissitudes, the English War of the Roses at the end of the 15th century, Abdurrahman soon became distinguished for ability and daring energy. Although his father, Afzul Khan, who had none of these qualities, came to terms with the Amir Sher Ali, the son's behaviour in the northern province soon excited the Amir's suspicion, and Abdurrahman, when he was summoned to Kabul, fled across the Oxus into Bokhara. Sher Ali threw Afzul Khan into prison, and a serious revolt followed in South Afghanistan; but the Amir had scarcely suppressed it by winning a desperate battle, when Abdurrahman's reappearance in the north was a signal for a mutiny of the troops stationed in those parts, and a gathering of armed bands to his standard. After some delay and desultory fighting, he and his uncle, Azim Khan, occupied Kabul (March 1866). The Amir Sher Ali marched up against them from Kandahar; but in the battle that ensued at Shekhabad on 10th May he was deserted by a large body of his troops, and after his signal defeat Abdurrahman released his father, Afzul Khan, from prison in Ghazni, and installed him upon the throne as Amir of Afghanistan. Notwithstanding the new Amir's incapacity, and some jealousy between the real leaders, Abdurrahman and his uncle, they again routed Sher Ali's forces, and occupied Kandahar in 1867; and when at the end of that year Afzul Khan died, Azim Khan succeeded to the rulership, with Abdurrahman as his governor in the northern province. But towards the end of 1868 Sher Ali's return, and a general rising in his favour, resulting in their defeat at Tinah Khan on January 3, 1869, forced them both to seek refuge in Persia, whence Abdurrahman proceeded afterwards to place himself under Russian protection at Samarkhand. Azim died in Persia in October 1869.

This brief account of the conspicuous part taken by Abdurrahman in an eventful war, at the beginning of which he was not more than twenty years old, has been given to show the rough school that brought out his qualities of resource and fortitude, and the political capacity needed for rulership in Afghanistan. He lived in exile for eleven years, until on the death, in 1879, of Sher Ali, who had retired from Kabul when the British armies entered Afghanistan, the Russian Governor-General at Tashkend sent for Abdurrahman, and pressed him to try his fortunes once more across the Oxus. In March 1880 a report reached India that he was in northern Afghanistan; and the Governor-General, Lord Lytton, opened communications with him to the effect that the British Government were prepared to withdraw their troops, and to recognize Abdurrahman as Amir of Afghanistan, with the exception of Kandahar and some districts adjacent. After some negotiations, an interview took place between him and Mr (afterwards Sir) Lepel Griffin, the diplomatic representative at Kabul of the Indian Government, who described Abdurrahman as a man of middle height, with an exceedingly intelligent face, and frank and courteous manners, shrewd and able in conversation on the business in hand. At the durbar on 22nd July 1880, Abdurrahman was officially recognized as Amir, granted assistance in arms and money, and promised, in case of unprovoked foreign aggression, such further aid as might be necessary to repel it, provided that he followed British advice in regard to his external relations. The evacuation of Afghanistan was settled on the terms proposed, and in 1881 the British troops also made over Kandahar to the new Amir; but Ayub Khan, one of Sher Ali's sons, marched upon that city from Herat, defeated Abdurrahman's troops, and occupied the place in July. This serious reverse roused the Amir, who had not at first displayed much activity. He led a force from Kabul, met Ayub's army close to Kandahar, and the complete victory which he there won forced Ayub Khan to fly into Persia. From that time Abdurrahman was fairly seated on the throne at Kabul, and in the course of the next few years he consolidated his dominion over all Afghanistan, suppressing insurrections by a sharp and relentless use of his despotic authority. Against the severity of his measures the powerful Ghilzaie tribe revolted, and were crushed by the end of 1887. In that year Ayub Khan made a fruitless inroad from Persia; and in 1888 the Amir's cousin, Ishak Khan, rebelled against him in the north; but these two enterprises came to nothing.

In 1885, at the moment when (see AFGHANISTAN) the Amir was in conference with the British Viceroy, Lord Dufferin, in India, the news came of a collision between Russian and Afghan troops at Panjdeh, over a disputed point in the demarcation of the north-western frontier of Afghanistan. Abdurrahman's attitude at this critical juncture is a good example of his political sagacity. To one who had been a man of war from his youth up, who had won and lost many fights, the rout of a detachment and the forcible seizure of some debateable frontier lands was an untoward incident; but it was no sufficient reason for calling upon the British, although they had guaranteed his territory's integrity, to vindicate his rights by hostilities which would certainly bring upon him a Russian invasion from the north, and would compel his British allies to throw an army into Afghanistan from the south-east. His interest lay in keeping powerful neighbours, whether friends or foes, outside his kingdom. He knew this to be the only policy that would be supported by the Afghan nation; and although for some time a rupture with Russia seemed imminent, while the Indian Government made ready for that contingency, the Amir's reserved and circumspect tone in the consultations with him helped to turn the balance between peace and war, and substantially conduced towards a pacific solution. Abdurrahman left on those who met him in India the impression of a clear-headed man of action, with great self-reliance and hardihood, not without indications of the implacable severity that has too often marked his administration. His investment with the insignia of the highest grade of the Order of the Star of India appeared to give him much pleasure.

From the end of 1888 the Amir passed eighteen months in his northern provinces bordering upon the Oxus, where he was engaged in pacifying the country that had been disturbed by revolts, and in punishing with a heavy hand all who were known or suspected to have taken any part in rebellion. Shortly afterwards (1892) he succeeded in finally beating down the resistance of the Hazára tribe, who vainly attempted to defend their immemorial independence, within their highlands, of the central authority at Kabul.

In 1893 Sir Henry Durand was deputed to Kabul by the Government of India for the purpose of settling an exchange of territory required by the demarcation of the boundary between north-eastern Afghanistan and the Russian possessions, and in order to discuss with the Amir other pending questions. The Amir showed his usual ability in diplomatic argument, his tenacity where his own views or claims were in debate, with a sure underlying insight into the real situation. The territorial exchanges were amicably agreed upon; the relations between the Indian and Afghan Governments, as previously arranged, were confirmed; and an understanding was reached upon the important and difficult subject of the border line of Afghanistan on the east, towards India. In 1895 the Amir found himself unable, by reason of ill-health, to accept an invitation from Queen Victoria to visit England; but his second son Nasrulla Khan went in his stead.

Abdurrahman died on the 1st October 1901, being succeeded by his son Habibulla. He had defeated all enterprises by rivals against his throne; he had broken down the power of local chiefs, and tamed the refractory tribes; so that his orders were irresistible throughout the whole dominion. His government was a military despotism resting upon a well-appointed army; it was administered through officials absolutely subservient to an inflexible will, and controlled by a widespread system of espionage; while the exercise of his personal authority was too often stained by acts of unnecessary cruelty. He held open courts for the receipt of petitioners and the dispensation of justice; and in the disposal of business he was indefatigable. He succeeded in imposing an organized government upon the fiercest and most unruly population in Asia; he availed himself of European inventions for strengthening his armament, while he sternly set his face against all innovations which, like railways and telegraphs, might give Europeans a foothold within his country. His adventurous life, his forcible character, the position of his State as a barrier between the Indian and the Russian empires, and the skill with which he held the balance in dealing with them, combined to make him a prominent figure in contemporary Asiatic politics, and will mark his reign as an epoch in the history of Afghanistan.

The Amir received an annual subsidy from the British Government of 18½ lakhs of rupees. He was allowed to import munitions of war. In 1896 he adopted the title of Zia-ul-Millat-ud-Din (Light of the nation and religion); and his zeal for the cause of Islam induced him to publish treatises on Jehad. His eldest son Habibulla Khan, with his brother Nasrulla Khan, was born at Samarkhand. His youngest son, Mahommed Umar Jan, was born in 1889 of an Afghan mother, connected by descent with the Barakzaie family.

See also S. WHEELER, F.R.G.S. *The Amir Abdur Rahman.* London, 1895.—*The Life of Abdur Rahman, Amir of Afghanistan, G.C.B., G.C.S.I.*, edited by MIR MUNSHI, SULTAN MAHOMMED KHAN. 2 vols., London, 1900. Also the article AFGHANISTAN. (A. C. L.)

Abel, Sir Frederick Augustus, BART. (1827- ——), English chemist, was born in London, 17th July 1827. Determining to adopt chemistry as his profession, he was one of the first students to enter the Royal College of Chemistry, which was established in 1845 under the direction of the distinguished German chemist, von Hofmann. After remaining there for six years, during five of which he acted as one of Hofmann's assistants, he became Professor of Chemistry at the Royal Military Academy in 1851, and three years later was appointed Chemist to the War Department and Chemical Referee to the Government. During his tenure of this office, which lasted until 1888, he carried out a large amount of work in connexion with the chemistry of explosives, one of the most important of his investigations having to do with the manufacture of gun-cotton. Continuing and supplementing the work of Lenk in Austria, he devised a process which enabled it to be prepared with practically no danger, and which at the same time yielded the product in a form that increased its usefulness. This consisted essentially in reducing the cotton, after nitration, to fine pulp. A double advantage was thereby gained; the material could be more certainly washed free from every trace of the acid which, if not removed, renders it liable to spontaneous combustion, while control over the rate of explosion, which is largely a question of mechanical condition, could be gained by hydraulic compression of the pulp into masses of whatever size and shape might be found desirable. These improvements in the manufacture of gun-cotton contributed in an important degree to the preparation of the smokeless powders, which in the latter part of the 19th century came into general use for military purposes all over the world. Cordite, the particular form adopted by the British Government, was the joint invention of Abel and Professor Dewar, who, with Dr Dupré, constituted the special Committee on Explosives which sat from 1888 to 1891 to select a smokeless powder for the British army and navy. For his services as chairman of this committee Abel was made a K.C.B. Our knowledge of the explosion of ordinary black powder was also greatly added to by him, and in conjunction with Sir A. Noble he carried out one of the most complete inquiries on record into its behaviour when fired. The invention of the apparatus, legalized in 1879, for the determination of the flash-point of petroleum, was another piece of work which fell to him by virtue of his official position. His first instrument, the open-test apparatus, was prescribed by the Act of 1868, but, being found to possess certain defects, it was superseded in 1879 by the Abel close-test instrument. The earlier Act imposed restrictions on the storage of petroleum having a flash-point below 100° F., as ascertained by the open-test instrument, and by the second one it was intended to maintain the same standard. It therefore became necessary to ascertain the relation between the two tests, and for this purpose Abel superintended a long series of experiments, which showed that, on the average, oil which flashed at 100° open-test flashed at only 73° close-test. The latter figure was therefore legalized as the equivalent of the former under the new conditions. Abel's researches were not confined to chemistry. In electricity he studied the construction of electrical fuzes and other applications of that form of energy to warlike purposes, and in 1877 he served as president of the Institution of Electrical Engineers (then the Society of Telegraph Engineers). Problems of steel manufacture also engaged his attention, and in 1891-93 he was president of the Iron and Steel Institute, whose Bessemer medal he was awarded in 1897. Of the Royal Society he became a member in 1860, receiving a Royal medal in 1887. He took an important part in the work of the Inventions Exhibition in 1885, and in 1887 became organizing secretary and first director of the Imperial Institute. Among the books he has published are *Handbook of Chemistry* (with Bloxam), *Modern History of Gunpowder* (1866), *Gun-cotton* (1866), *On Explosive Agents* (1872), *Researches in Explosives* (1875), and *Electricity applied to Explosive Purposes* (1884). He also wrote several important articles in the ninth edition of the *Encyclopædia Britannica.*

Abeokuta. See LAGOS.

Aberavon, a municipal and contributory parliamentary borough and railway station of Glamorganshire, Wales, near the mouth of the Avon, 11 miles E.S.E. of Swansea. It belongs to the Swansea parliamentary district of boroughs. The port of Aberavon is Port Talbot, where there is a dock over a mile long, and from 240 to 900 feet wide. Area of municipal borough, 2060 acres. Population in 1881, 4859; in 1891, 6300; in 1901, 7553.

Abercarn, a large village in the southern parliamentary division of Monmouthshire, England, 10 miles N.W. from Newport by rail. There are collieries and ironworks in the district. The urban district includes part of the civil parish of Mynyddyslwyr; area, 9504 acres; population in 1881, 5964; in 1891, 10,464; in 1900, 12,607.

Aberconway. See CONWAY.

Aberdare, a market-town and railway station of Glamorganshire, Wales, 4 miles S.W. of Merthyr Tydfil, of which parliamentary borough it forms part. The town has continued to advance rapidly both in numbers and in general prosperity. The new erections include Established and Presbyterian churches, an infectious diseases hospital, a cottage hospital, a theatre, a memorial hall, a theological college, and a technical and intermediate school; there is also a commodious industrial training school, and the town now possesses two extensive public parks. Besides the prosperous mineral industries, there are brick and pottery works, and several breweries. Population of township in 1881, 35,533; in 1891, 40,917; of urban district in 1891, 38,431; in 1901, 43,357.

Aberdeen, a royal burgh, city, and county of a city (1899), and the county town of Aberdeenshire, Scotland, situated on a bay between the mouths of the rivers Dee and Don, 111 miles N. of Edinburgh by road and 130½ by rail (Forth Bridge route). The city has grown and prospered in an exceptional degree during the past half-century, owing to the development of the trawling industry, its educational facilities, and the attractions it offers to residents. In 1883, 900 acres were added to the municipal area, which was further extended in 1891 from 2681 to 6602 acres, incorporating in the city the burghs of Old Aberdeen and Woodside, and the district of Torry on the other side of the Dee. A large number of handsome streets have been laid out, and 200 to 400 buildings have been erected annually at a total estimated cost of £150,000 to £350,000. An esplanade is being laid out along the sea-beach, and a boulevard constructed round the city. Union Terrace Gardens are now public, and Duthie Park (44 acres), lying on the north bank of the Dee, has been opened; it is adorned with a granite statue of Hygeia in honour of the donor. The latest addition to the parks is Stewart Park (13½ acres). By the introduction of a freer treatment of granite the architecture of the city generally has been much improved in recent years. Marischal College has been rendered a still more striking feature of Aberdeen. Under an extension scheme to which the Treasury contributed £40,000, the Town Council £23,350, and one donor between £20,000 and £30,000, a splendid graduation hall has been built, considerable additions have been made to the class-room accommodation, and the edifice has been crowned by a lofty and imposing tower, while the front, long concealed by mean houses, has been largely opened up. King's College also has been extended, and the chapel reconstructed internally and decorated. A botanic garden was presented to the university in 1899, and the opening of the Mitchell Hall coincided with the celebration of the quatercentenary of the university in 1895. Two viaducts carrying streets have been constructed, and Victoria Bridge over the Dee opened. The East church, burned down in 1874, has been rebuilt, and a massive granite tower erected over the aisle connecting it with the West church. This tower has been furnished with a Jubilee peal of 36 bells. The New Market, destroyed by fire in 1882, was rebuilt in 1883. Perhaps the most important of the new public buildings is the Museum and Art Gallery and School of Art (Italian Renaissance in red and brown granites) opened in 1883 and 1884. Other recently erected public buildings are new harbour offices, new fish market, new School Board offices, free library, theatre, Union Club, bathing station, Salvation Army Citadel (on a prominent site), and new Parish Council Chambers. The Royal Infirmary has been largely rebuilt since 1887 as a memorial of Queen Victoria's Jubilee, and Trinity Hall has been extended. St Mary's Chapel has been restored, and a dozen or more new churches have been built within the last few years. A large extension of the railway station was authorized in 1899. New statues are Queen Victoria in bronze (1893), General Gordon (1888), Sir William Wallace (colossal bronze) (1888), and Burns in bronze (1892).

Aberdeen has been represented in Parliament since 1885 by two members, who sit for the north and south divisions. The Town Council has now 34 members, including six magistrates. The two parishes of St Nicholas and Old Machar were amalgamated by the Local Government Act of 1894, and the poor law is administered by a parish council of 31 members. The Town Council began in 1899 to work the tramways; one of the routes has been equipped for overhead electric traction. Electric light has been introduced by the Corporation. Extensive improvements of the harbour accommodation have been made, including the construction of a graving dock, which has proved a failure and is being rebuilt; a bridge across the docks is being constructed. The harbour revenue rose from £32,229 in 1871 to £68,849 in 1899. At the end of 1898, 201 vessels of 96,682 tons were registered at the port, and the movements of shipping were—1888, entered 2706 vessels of 726,886 tons, cleared 2649 vessels of 703,162 tons; 1898, entered 3117 vessels of 936,409 tons, cleared 3349 vessels of 934,175 tons. Imports were valued at £662,102 in 1888 and £927,624 in 1898; exports £135,382 in 1888 and £145,118 in 1898. The customs revenue at the port averaged £82,384 a-year in 1894-98. The granite industry continues to progress, but the most striking development has been in the fishing industry. Beam-trawling was introduced in 1882, and steam line fishing in 1889. Now there are 83 trawlers registered at the port, and 52 more make Aberdeen their headquarters. These are manned by 1140 men, and the capital invested in boats and gear is estimated at over £700,000. During 1899 there were in all 7700 arrivals. Fifty foreign smacks and luggers made landings during the year. In 1899, 886,037 tons of fish were landed which were valued at £537,422, and of that quantity 687,814 tons of £434,885 were trawl fish. A fresh impetus has been given recently to linen manufacture. Shipbuilding, which at one time threatened to decay, has been revived by the trawling industry; 11 vessels of 9380 tons were launched in 1889 and 28 vessels of 11,973 in 1899. The university has now 24 professors and 12 lecturers, mostly of recent institution, and its scholarships and bursaries are of £7608 annual value, a bequest of £20,000 for this purpose having been made in 1897. Matriculated students numbered 753 in session 1898-9. Gordon's Hospital was transformed in 1881 into Gordon's College, a day and night secondary school, in which special attention is paid to scientific and secondary education. The grammar school for boys and a high school for girls are under the School Board, and there are several private higher-class schools. An Educational Trust constituted under the Endowments Act of 1882 possesses a capital of £155,000. Valuation in 1889-90, £550,802; 1899-1900, £753,802. Population in 1881, 105,003; 1891, 121,623; 1901, 153,108.

AUTHORITIES.—J. GORDON. *Description of Both Towns of Aberdeen.* Spalding Club, 1842.—W. KENNEDY. *Annals of Aberdeen.* London, 1818.—JOS. ROBERTSON. *The Book of Bon-Accord.* Aberdeen, 1839.—W. ROBBIE. *Aberdeen: Its Traditions and History.* Aberdeen, 1893.—C. G. BURR and A. M. MUNRO. *Old Landmarks of Aberdeen.* Aberdeen, 1886.—A. M. MUNRO. *Memorials of the Aldermen, Provosts, and Lord Provosts of Aberdeen.* Aberdeen, 1897.—P. J. ANDERSON. *Charters, &c., illustrating the History of the Royal Burgh of Aberdeen.* Aberdeen, 1890.—*Idem. Selections from the Records of Marischal College.* New Spalding Club, 1889, 1898-9.—J. COOPER. *Chartulary of the Church of St Nicholas.* New Spalding Club, 1888, 1892.—G. CADENHEAD. *Sketch of the Territorial History of the Burgh of Aberdeen.* Aberdeen, 1876.—W. CADENHEAD. *Guide to the City of Aberdeen.* Aberdeen, 1897.—A. SMITH. *History and Antiquities of New and Old Aberdeen.* Aberdeen, 1882. (W. WA.)

Aberdeenshire, a maritime county of N.E. Scotland, bounded N. and E. by the German Ocean, S. by the counties of Kincardine and Perth, and W. by Banff and Inverness shires.

Area and Population.—In 1891 the Banffshire portions of the parishes of Gartly, Glass, New Machar, Old Deer, and St Fergus were transferred to Aberdeenshire, and the Aberdeenshire portion of the parish of Cabrach to Banffshire. Of parishes partly in Aberdeen and partly in Kincardine, Drumoak was placed wholly in the former and Banchory-Ternan in the latter county. According to the latest official estimate the area of the county (foreshore excluded), is 1,268,705 acres, or about 1982 square miles. The population was in 1881, 267,990; in 1891, 281,332; in 1891 on the extended area, 284,036, of whom 135,185 were males, and 148,851 females. On the old area, taking land only (1,251,451 acres, or 1955·4 square miles), the number of persons to the square mile in 1891 was 144, and the number of acres to the person 4·4. In the registration county the population increased between 1881 and 1891 by 4·83 per cent. In 1901 the population was 304,420, an increase of 20,384. The following table gives particulars of the births, deaths, and marriages in 1880, 1890, and 1899:—

Year.	Marriages.	Births.	Deaths.	Percentage of Illegitimate.
1880	1700	9099	4472	14·4
1890	1743	8436	5205	12·98
1899	2283	9135	4884	11·2

The birth-rate, death-rate, and marriage-rate were all below the rates for Scotland. The following table gives the birth-rate, death-rate, and marriage-rate per thousand of the population for a series of years:—

	1880.	1881-90.	1890.	1891-98.	1899.
Birth-rate . .	34·05	32·15	30·02	31·08	31·04
Death-rate . .	16·73	18·77	18·52	16·72	16·59
Marriage-rate .	6·36	6·23	6·20	7·25	7·75

According to the census of 1891 there were in the county 1538 Gaelic-speaking persons, of whom 8 spoke Gaelic only, and there were 204 foreigners. Valuation in 1889-90, £858,173; 1899-1900, £920,246.

Administration.—The county returns two members to Parliament—for the East and West divisions respectively. Besides the county town, Aberdeen (121,823), which returns two members, there are in the county two royal and parliamentary burghs, Inverurie (3105) and Kintore (886), and one parliamentary burgh, Peterhead (12,195), all of which belong to the Elgin group of burghs for parliamentary representation. Important police burghs are Huntly (3780), Fraserburgh (7466), and Turriff (2341). There are 82 civil parishes, 24 of which belong to the Buchan Combination, with a poorhouse at Maud, while the city parish has poorhouses in Aberdeen. The number of paupers and dependants in September 1899 was 5898. The county forms a sheriffdom with Banff and Kincardine, and there are two resident sheriffs-substitute in Aberdeen, who sit also at Peterhead, Fraserburgh, Huntly, and Turriff.

Education.—Ninety-two school boards manage 258 schools, which had an average attendance of 48,388 in 1898-99, while 38 voluntary schools, of which 14 are Episcopal and 8 Roman Catholic, had 5507. There are 3 higher-class schools in Aberdeen, and secondary schools at Huntly, Peterhead, and Fraserburgh, and 69 other schools in the county earned grants in 1898 for giving secondary education. The County Secondary Education Committee dispensed £4253 in 1899, of which £2247 came from the Education Department and £2006 was contributed by local authorities from the "residue" grant, and supported, besides the schools mentioned, local classes and itinerant lectures in agriculture, fishery, and other technical subjects, besides subsidizing the agricultural department of the university of Aberdeen.

Agriculture.—In no county in Scotland has a more productive soil been made out of unpromising material during the 19th century. Oats are the predominant crop, but the barley acreage has been nearly doubled since 1872, while wheat has practically gone out of cultivation. The most distinctive industry is cattle-feeding. A large number of the home-bred crosses are fattened for the London and local markets, and Irish animals are imported on a large scale for the same purpose. An exceedingly large business in the sale of live stock and dead meat is done all over the county, and the average weekly export of dead meat from Aberdeen for the London and southern markets has been estimated at 150 to 200 tons, while the shipment of cattle for the same destinations averages 50 to 70 head weekly. The following table gives the principal acreages at intervals of five years from 1880:—

Year.	Area under Crops.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1880	603,226	212,767	104,203	259,645	25,861	748
1885	611,424	215,950	102,489	263,004	29,372	826
1890	614,365	213,887	101,243	268,058	30,290	543
1895	630,070	215,730	101,709	276,389	35,711	196
1899	630,121	214,920	100,109	283,968	30,563	184

The following table gives particulars of the live stock during the same years:—

Year.	Total Horses.	Total Cattle.	Cows or Heifers in Milk or Calf.	Sheep.	Pigs.
1880	26,851	152,106	41,318	137,893	7,240
1885	25,963	188,008	45,235	158,587	10,781
1890	26,637	163,240	43,261	195,689	12,061
1895	31,114	178,961	43,497	183,951	10,379
1899	30,330	175,407	45,540	232,863	12,848

Aberdeenshire has by far the largest cultivated area of any county in Scotland, and the largest number of holdings, but the percentage of cultivation is only 49·6. Of the 11,567 holdings in 1895, the average size was 54 acres. The percentage under 5 acres was 14·37; between 5 and 50 acres 49·23, and over 50 acres 36·40. Farms between 50 and 100 acres numbered 2164, between 100 and 300, 1912; between 300 and 500, 124, and between 500 and 1000, 10; there were none above 1000 acres. According to the census of 1891 there were 28,386 men and 1213 women engaged in agriculture. The acreage under wood in 1895 was 106,976, of which 7986 had been planted since 1881.

Industries and Trade.—There are now a number of paper-making establishments in the shire, most of them on the Don in the vicinity of Aberdeen. Aberdeen is the premier granite county in the kingdom. There are quarries at Aberdeen, Kemnay, Peterhead, and elsewhere, and the output was 242,168 tons valued at £132,373 in 1895, and 335,075 tons valued at £176,481 in 1899. Quarrying and dressing the stone gave employment in 1891 to 8294 persons. Fishing, however, is the next most important industry to agriculture. The nineteen ports and creeks of the county are divided into the three fishery districts of Peterhead, Fraserburgh, and Aberdeen, the last of which includes also three Kincardineshire ports. The following table gives statistics of the three districts jointly in 1890, 1898, and 1899:—

Year.	Boats.			Value of Gear.	Resident Fishermen and Boys.	Total Value of all Fish.
	No.	Tons.	Value.			
1890	1503	18,991	£193,817	£153,895	4822	£556,857
1898	1530	22,306	£497,659	£187,668	3929	£883,129
1899	1438	22,959	£731,534	£184,243	5417	£968,805

The number of persons in the three districts employed in the various branches of the sea fisheries was 21,232 in 1899. Between a half and a third of the catch consists of herrings. The herring season for Aberdeen, Peterhead, and Fraserburgh is from June to September, at which time the ports are crowded with boats from other Scottish districts. The development of the fisheries of late years has been due to the trawlers almost exclusively. (See ABERDEEN.) There are valuable salmon fishings—rod, net, and stake-net—on the Dee, Don, Ythan, and Ugie. The average annual despatch of salmon from Aberdeenshire during the years 1894 to 1898 was about 400 tons. A branch (15½ m.) of the Great North of Scotland Railway was opened in 1897, and a light railway (13 m.) has been sanctioned.

AUTHORITIES.—A. SMITH. *New History of Aberdeenshire.* Aberdeen, 1875.—W. WATT. *History of Aberdeen and Banff.* Edinburgh, 1900.—SIR A. LEITH-HAY. *Castles of Aberdeenshire.* Aberdeen, 1887.—J. DAVIDSON. *Inverurie and the Earldom of the Garioch.* Edinburgh, 1878.—W. TEMPLE. *The Thanage of Formartyn.* Aberdeen, 1894.—PRATT. *Buchan* (rev. by R. Anderson). Aberdeen, 1900.—A. I. M'CONNOCHIE. *Deeside.* Aberdeen, 1895. *The Royal Dee.* Aberdeen, 1898. *Queen Victoria's Highland Home.* Aberdeen, 1897.—W. FERGUSON. *The Great North of Scotland Railway.* Edinburgh, 1881.—A. JERVISE. *Epitaphs and Inscriptions.* Edinburgh, 1875, 1879.—*Transactions of Buchan Field Club.* Peterhead, 1887.—*A Guide to Donside.* Aberdeen, 1866. (W. WA.)

Abergavenny, a municipal borough (1899), market-town, and railway station, in the northern parliamentary division of Monmouthshire, England, at the confluence of the Gavenny and the Usk, 16 miles W. of Monmouth. The lunatic asylum has been enlarged and a cottage hospital built. Population of urban district (borough) in 1891, 7743, on an area of 825 acres; in 1901, 7795; of parish in 1881, 7886; in 1891, 9036.

Aberystwith, a municipal borough, market town, and seaport of Cardiganshire, Wales, at the confluence of the Ystwith and Rheidol, 244 miles from London by rail. It ceased to be a parliamentary borough in 1885. Modern erections are two Established churches, Wesleyan and Welsh Calvinist chapels, a pier pavilion, a ladies' hostel in connexion with the University College of Wales, baths, and a new infirmary. The University College of Wales was opened in 1872, and in 1900 had 31 professors and 474 students. In the town and neighbourhood are engineering works, foundries, and slate-quarries. The corporation is lord of the manor, and owns nearly four-fifths of the town. Population in 1881, 7088; in 1891, 6725; in 1901, 8013. Area, 845 acres.

Abeshr. See WADAI.

Abila, (1) the capital of the tetrarchy of Abilene, was an important town on the imperial highway from Damascus to Heliopolis (*Baâlbek*), and is now represented by Suk Wádi Baradá, a village called by early Arab geographers Ábil es-Súk. The tetrarchy was granted by Caligula, 37 A.D., to Agrippa I., and by Claudius, 52 A.D., to Agrippa II. (2) A city in Perea, now Ábil ez-Zeit.

Abingdon, a municipal borough and market town in the Abingdon parliamentary division (since 1885) of Berkshire, England, 61 miles W.N.W. of London by rail The old churches of St. Helen and of St. Nicholas have been restored, a corn exchange, a cottage hospital, and a free public library erected, and municipal drainage works and water works executed. The town has important corn markets and horse fairs. Area of borough, 730 acres. Population in 1881, 6755; in 1891, 6557; in 1901, 6480.

Åbo, city and seaport of Finland, Russia, capital of the Abo-Björneborg province; 381 miles by rail from St Petersburg, *viâ* Tavastehus; in regular steamer communication with St Petersburg, Wasa, and Stockholm. Shipbuilding has considerably developed lately, warships being built for the Russian navy. This city is only second in Finland to Helsingfors for its trade. Its harbour (Bornholm, on Hyrvinsala Island) is entered yearly by from 700 to 800 ships, of about 200,000 tons. Population, 18,109 in 1867; 34,339 in 1897.

Abo-Björneborg, a province occupying the S.W. corner of Finland, and including the Åland islands. Its population reached 413,351 in 1897, of whom 12 per cent. lived in towns. It occupies the first rank in Finland for its manufactures of cottons, sugar refinery, wooden goods, metals, machinery, paper, &c. Its chief towns are —Abo, Marienhaven (759), Nodendal (654), Nystad (4023), and Raumo (4111).

Abomey. See DAHOMEY.

About, Edmond François Valentin (1828-1885), French novelist, publicist, and journalist, was the son of a grocer, and was born on the 14th of February 1828, at Dieuze, in Lorraine. The boy's school career was brilliant. In 1848 he entered the École Normale, taking the second place in the annual competition for admission, Taine being first. Among his college contemporaries were Taine, Paul Albert, Weiss, Assolant, Sarcey, Challemel-Lacour, the ill-starred Prevost-Paradol. Of them all About was, according to Sarcey (*Souvenirs de Jeunesse*), the most highly vitalized, exuberant, brilliant, and "undisciplined." At the end of his college career he joined the French school in Athens, but if we may believe his own account, it had never been his intention to follow the professorial career, for which the École Normale was a preparation, and in 1853 he returned to France and frankly gave himself to literature and journalism. A book on Greece, *La Grèce contemporaine* (1855), which did not spare Greek susceptibilities, had an immediate success. *Tolla*, which remains one of his best novels, appeared shortly after, and during the next few years, with indefatigable energy, and generally with full public recognition, he wrote novels, stories, a play—which failed—a book-pamphlet on the Roman question, many pamphlets on other subjects of the day, newspaper articles innumerable, some art criticisms, rejoinders to the attacks of his enemies, and popular manuals of political economy, *L'A B C du Travailleur*, *Le Progrès*. About's attitude towards the empire was that of a candid friend. He believed in its improvability, greeted the Liberal ministry of Emile Olivier at the beginning of 1870 with delight, and welcomed the Franco-German war. That day of enthusiasm had a terrible morrow. For his own personal part he lost the loved home near Saverne in Alsatia, which he had purchased in 1858, out of the fruits of his earlier literary successes. With the fall of the empire he became a Republican, and, always an inveterate anti-clerical, he threw himself with ardour into the battle against the conservative reaction which made head during the first years of the Republic. From 1872 onwards for some five or six years his paper, the *XIX^e^ Siècle*, of which he was the heart and soul, became a power in the land. But the Republicans never quite forgave the tardiness of his conversion, and no place rewarded his later zeal. On the 23rd January 1884 he was elected a member of the French Academy, but died on the 26th January 1885, before taking his seat. Dust has accumulated on the mass of About's work. His journalism—of which specimens in his earlier and later manners will be found in the two series of *Lettres d'un bon jeune homme à sa Cousine Madeleine* (1861 and 1863) and *Le Dix-neuvième Siècle* (1892)—was of its nature ephemeral. So were the pamphlets, great and small. His political economy was that of an orthodox popularizer, and in no sense epoch-making. His dramas are negligible. His more serious novels, *Madelon*, *L'Infâme*, the three that form the series of the *Vieille Roche*, and *Le Roman d'un brave homme*—a kind of counterblast to the view of the French workman presented in M. Zola's *Assommoir*—contain striking and amusing scenes no doubt, but scenes which are often suggestive of the stage, while description, dissertation, explanation too frequently take the place of life. His best work after all is to be found in the books that are almost wholly farcical, *Le nez d'un notaire*, *Le Roi des Montagnes*, *L'Homme à l'oreille cassée*, *Trente et quarante*, *Le Cas de M. Guérin*. Here his most genuine wit, his sprightliness, his vivacity, the fancy that was in him, have free play. "You will never be more than a little Voltaire," said one of his masters when he was a lad at school. It was a true prophecy.

(F. T. M.)

Abrudbánya, a corporate town of S.E. Hungary, situated on the slope of the Érczhegység (Ore Mountains), 43 miles S.W. by S. of Klausenburg (*Hung.* Kolozsvar). In Roman times it was the site of a town where resided the *procurator aurarium* of Dacia, and gold ore is still mined in the villages on the neighbouring mountains. The annual produce of these mines is about 34,400 oz. troy of fine gold. Considerable secondary products are silver, iron, copper, lead, and lignite. The ore raised from the mines belonging to the mine-captaincy of Falatna (to which Abrudbánya belongs) in 1899 represented a total value of £972,292. Population (1891), 2992; (1901) 3370; of recent years it has become joined to the village of Abrudfalva with (1901) 4978 inhabitants. It contains good state schools and many handsome buildings.

Abruzzi e Molise, a territorial division of Italy, a mountainous region embracing the middle Apennines and reaching down to the Adriatic on the E. It comprises the provinces of Aquila, Chieti, Teramo, and Campobasso, with an area of 6567 sq. miles, and includes a population of (1881) 1,317,215, (1901) 1,442,365. The first three provinces correspond to the former Neapolitan districts of Abruzzo, and Campobasso to the former Neapolitan province of Molise. The mountains are in great part covered with forests, and the wealth of the people consists principally in cattle, sheep, and pigs. Some wheat, wine, olives, and figs are grown in the valleys. Beyond the rearing of silkworms and silk-spinning, the industries are unimportant. The towns are mostly of small size, the chief of them being Chieti, Teramo, Aquila, Campobasso, and Solmona.

Abt, Franz (1819-1885), German composer, was born 22nd December 1819 at Eilenburg, Saxony, and died at Wiesbaden, 31st March 1885. The best of his popular songs have become part of the recognized folk-music of Germany; his vocal works, solos, part-songs, &c., enjoyed an extraordinary vogue all over Europe in the middle of the 19th century, but in spite of their facile tunefulness have few qualities of lasting beauty. He was Kapellmeister at Bernburg, 1841, at Zurich in the same year, and at Brunswick, 1852-82, when he retired to Wiesbaden.

Abu, a mountain of India, in the Sirohi state of Rajputana, being an isolated spur of the Aravalli range. It is situated in 24° 35′ N. lat. and 72° 45′ E. long., 16 miles from the Abu road station of the Rajputana railway. The height above the sea of the various peaks ranges from about 4000 to 5635 feet. It is the summer residence of the governor-general's agent for Rajputana, and a place of resort for Europeans in the hot weather. The annual mean temperature is about 70°, rising to 90° in April; but the heat is never oppressive. The annual rainfall is about 68 inches. The hills are laid out with driving-roads and bridle-paths, and there is a beautiful little lake. The chief buildings are a church, club, hospital, and a Lawrence asylum school for the children of British soldiers.

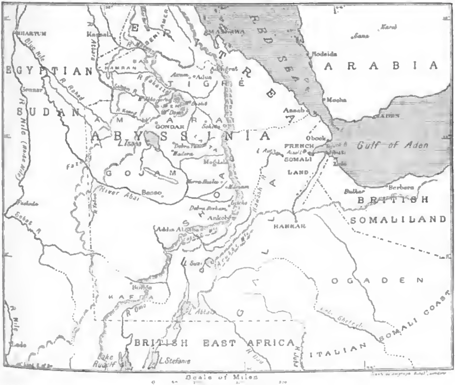
Abu Ahmed. See SUDAN, ANGLO-EGYPTIAN.

Abushehr. See BUSHIRE.

ABYSSINIA.

1. GEOGRAPHY AND STATISTICS.

DURING the last thirty years of the 19th century our knowledge of the physical features, climate, natural history, resources, and social condition of Abyssinia has been greatly advanced by scientific exploration, by hunting and military expeditions, and by the reports of numerous embassies to the courts of its successive rulers. As fully explained in the historical section (see below), a main result of the political relations, some friendly, some hostile, with Egypt, Italy, and Great Britain, has been the consolidation of the Abyssinian empire under one potentate, Menelek, king of Shoa, by the complete reduction of the ancient kingdoms of Tigré, Lasta, Amhara, and Gojam, followed by the absorption of all the surrounding Ethiopian lands. The area of the unified political system has thus been enlarged, especially in the direction of the south and south-east, while its absolute autonomy has been recognized by various international treaties with Great Britain and Italy. Menelek's dominions now comprise the whole of the Galla and Kaffa highlands, extending from Abyssinia proper southwards nearly to the Samburu (Lake Rudolf) depression, together with Harrar and Central Somaliland coterminous with the French, British, and Italian possessions along the seaboard. In the empire are thus now included, besides the above-mentioned vassal kingdoms, the territories of Ennarea, Guragheh, Walamo, Jimma, Ghera, Guma Leka, Walega, Kaffa, and all the other petty states which are exclusively occupied by the Hamitic Galla people, and constitute what is commonly called Gallaland or South Ethiopia. The frontiers, mostly conventional lines regardless of mountain ranges, river basins, or other natural features, have not yet been determined towards the N.W., W., and S.; but they roughly coincide on the west towards



SKETCH MAP OF ABYSSINIA.

the Anglo-Egyptian Sudan, with the meridian of 35° E. between the river Rahad, and 4° N. lat., and on the south with this parallel eastwards to 40° E. Here the line is deflected irregularly south-eastwards to Logh, on the river Juba, and then runs north by east at about 180 miles from the coast along the Italian frontier as far as British Somaliland. Beyond this district the boundary is coterminous eastwards with French Somaliland as defined in 1897, and the Italian colony of Eritrea as far north as 15° N. lat., and westwards to the Atbara, whence the line runs south and west to the point where the river Rahad is intersected by the meridian of 35° E. Within these limits the reconstituted Abyssinian empire has a total area of about 320,000 square miles, with a population approximately estimated at 9,000,000 distributed as under:—

	Area in Sq. Miles.	Population.
Hamran, Beni-Amer, Bilin, Merea, Mensa, Basé (Kunama), and Barea districts between the Plateau and Upper Nubia	30,000	150,000
Abyssinia proper (North Ethiopia): the old kingdoms of Tigré, Lasta, Amhara and Gojam	80,000	2,600,000
Shoa (Menelek's patrimony) . .	20,000	1,000,000
Harrar and neighbouring districts	10,000	250,000
Ogaden and other parts of Somaliland	100,000	1,000,000
South Ethiopia (Gallaland) . .	80,000	4,000,000
Total (1901) . .	320,000	9,000,000

Despite its enlarged domain, Abyssinia still remains an inland state, nowhere reaching the coast, where all its natural outlets—Massawa and Assab on the Red Sea, Jibuti, Zeila, Bulhar, and Berbera on the Gulf of Aden—are held by foreign Powers. Even on the west side it is cut off from direct access to the White Nile, where both banks of the river are included in the Anglo-Egyptian Sudan. No doubt the upper courses of the eastern affluents of the main stream, Sobat, Abai (Blue Nile), Takazzé (Atbara, or Black Nile), flow through Abyssinian territory. But here they have the character of intermittent wadies, nearly dry for a great part of the year, and during the rains raging torrents rushing wildly through deep rocky gorges down to the lowlands, hence at no time navigable, and of little use even for irrigation purposes. Hence their exclusion from marine and fluvial navigable waters has been all the more acutely felt by the native rulers, whose foreign policy continues to be largely directed towards acquiring territory both on the seaboard and along the right bank of the White Nile.

Physical features.

The Ethiopian highlands, of which Abyssinia proper forms the northern, and Gallaland the southern section, occupy most of the space between the lowlands of the White Nile basin and those of the Eritrean rift valley, separating them from the Red Sea and the Indian Ocean. Their long axis is disposed in the direction of the meridian, and the whole region broadens out from near the Red Sea at Massawa southwards to the Lake Rudolf depression. The northern section, lying mainly between 10°-15° N. lat., may be described as a huge mass of Archaean gneiss and schists, forming a rugged plateau at a mean height of from 7000 to 7500 feet above the sea, profoundly weathered by sub-aerial agencies, and flooded in a deep central depression by the waters of Lake Tsana. Above the plateau, which presents its steepest escarpments towards the rift valley, and falls in terraces northwards and westwards down to the plains of Upper Nubia and Sennar, rise several irregular and generally ill-defined mountain ranges, consisting partly of Jurassic limestones and partly of old igneous rocks, great sheets of lava and vast piles of volcanic detritus, which in the western provinces of Gojam and Simen attain altitudes of from 12,000 to 15,000 or even 16,000 feet. But there appear to be nowhere any active cones, and the very craters have for the most part been obliterated. The plateau formation itself is broken and largely obscured by vast yawning chasms and fissures, through which the surface waters escape to the surrounding lowlands. Amid the chaos of Alpine heights and rugged plains which, seen from the higher summits, present the aspect of a storm-tossed sea suddenly solidified, the best-defined mountain system is the coast range, which is formed by the precipitous eastern escarpments of the plateau, and maintains for a distance of about 600 miles a mean elevation of from 7000 to 8000 feet. It thus rises little above the inland plateau, and travellers penetrating from the coast to the interior find that on surmounting this rocky barrier they have already reached the normal level of the whole region. But the irregular Simen and Gojam groups, the true highlands of North Ethiopia, still rise 6000 or 7000 feet higher, several of their peaks penetrating to the snow-line. Mount Dajan in the Simen range is certainly over 15,000 feet, and was long supposed to be the loftiest summit in Africa north of Kenia. But it now appears to be overtopped by others, such as Abba-yared (15,600 feet), and Buahit (16,000 feet) in the same group. At Ankober (9° N.) the coast range begins to trend round to the south-west, thus assuming the aspect of an inland chain, and gradually increasing in height until it culminates in Mount Metatiteh (11,000 feet), and the Entoto range crossed by the Hular Koh Pass (over 12,000 feet) in the kingdom of Shoa. Here the Abyssinian system merges in the South Ethiopian highlands, which are continued at considerable altitudes southwards to the Kaffa territory, and then fall rapidly down to the Lake Rudolf depression. Like the northern section, these less-known Galla uplands appear to form a much broken hilly plateau, presenting its steepest escarpments on the east side towards Somaliland, and falling more gently in a series of broad terraces down to the lowlands of the Nile basin. Although the routes of the explorers in the Galla and Samburu lands have now been connected by the itineraries of Bottego, Donaldson Smith, Wellby and a few other travellers, no accurate surveys have yet been made, and the heights assigned to the loftier peaks in South Ethiopia (Hamdo, 11,500 feet; Wariro, 13,000 feet; Wosho, 16,000 feet) are little more than conjectural. This region, however, is known to be of a far less rugged character than the Abyssinian tableland, and there are few or no traces of the so-called "ambas," that is, isolated blocks or sections caused by erosion and underground agencies, which are such a characteristic feature of the Shoa and Gojam uplands. Some of the intervening rifts and fissures, which somewhat resemble the Mexican barrancas, are of vast extent and depth, but often very narrow. The most remarkable occur along the edge of the central plateau, "where the total fissure exceeds 6500 feet, measured from the summit of the degas (uplands) down to sea-level. Nowhere else can a more convincing proof be observed of the erosive action of running waters. The two walls of certain gorges, rising nearly vertically within a few feet of each other to a height of some hundreds of feet, represent an erosion of hard rock amounting to at least 10,500 million cubic feet" (*Reclus*, x. p. 129).

Rivers and lakes.

Most of the Abyssinian uplands have a decided north-westerly tilt, so that nearly all the large rivers find their way in this direction inland to the Nile Valley. Such are the Takazzé in the north, the Abai in the centre, and the Sobat in the south, and through these three arteries is discharged about four-fifths of the entire drainage. The rest is carried off by the Khor Baraka, which occasionally reaches the Red Sea below Suakim; the Hawash, which runs out in the saline lacustrine district near the head of Tajura Bay; the Webi-Shebeyli and Juba, which flow through Somaliland to the Indian Ocean; and the Omo, now known to be the main feeder of the closed basin of Lake Rudolf. The Takazzé, which is the true upper course of the Atbara (the *Astaboras* of the ancients, and the *Bahr-el-Aswad* or "Black Nile" of the Arabs), has its source in the Simen uplands, and falls from about 7000 to 2500 feet above sea-level in the tremendous crevasse through which it sweeps round east, north, and west down to the western terraces, where it passes from Abyssinian to Nubian territory. During the rains the Takazzé, *i.e.*, the "Terrible," rises some 18 feet above its normal level, and at this time forms an impassable barrier between the northern and central provinces. In the Hamran district, where it becomes the Bahr-Setit, the Takazzé is joined on its left bank by the Upper Atbara, which is formed by the junction of the Angreb, Salaam, Aradeh, Koang, and several other head-streams descending from the Amhara uplands. Below the confluence the united stream retains the name of Atbara, and farther down receives on its right bank the intermittent waters of the Mareb or Gash, which rises near Adua in Tigré and is dry for a great part of the year, but, like the Takazzé, is subject to sudden freshets during the rains. From its source to the Nile confluence at Ed-Damer, where it is now crossed by a railway bridge, the main stream has a total length of about 800 miles, and the drainage area exceeds 20,000 square miles within Abyssinian territory. But the discharge is slight except in the wet season, when it nearly equals that of the Blue Nile. In its lower reaches it rises at times to a height of 30 or 40 feet, with a breadth of over 600 yards. The Abai—that is, the upper course of the Blue Nile—has its farthest source near Mount Denguiza, in the Gojam highlands, about 11° N. and 55° E., and first flows for 70 miles nearly due north to the south side of Lake Tsana (Dembea). This great island-studded basin, which stands some 3000 feet below the normal level of the plateau, has somewhat the aspect of a flooded crater, being of nearly circular form, with a diameter of about 40 miles, an area of over 1200 square miles, and a depth in some parts of 250 feet. Tsana has been identified with the *Coloe Palus* of the ancients, which, although placed some 12° too far south by Ptolemy, was described as a chief reservoir of the Egyptian Nile and the source of the *Astapus*, which was certainly the Blue Nile. At the south-east corner the rim of the crater is, as it were, breached by a deep crevasse through which the Abai escapes, and here develops a great semicircular bend like that of the Takazzé, but in the reverse direction—east, south, and north-west—down to the plains of Sennar. In this section of its course its swirling waters rush over a long series of cataracts and rapids, descending from a height of 6000 feet at the outlet to about 1400 feet at Fazokl, where it crosses the Abyssinian frontier, and flows with a sluggish current through the plains of Sennar to its confluence with the White Nile at Khartum, 1300 feet above sea-level. At Fazokl, where it becomes the *Bahr-el-Azreq* (Blue Nile), it is joined on its left bank by the auriferous Tumat, and higher up by the Yabus, both intermittent affluents from the South Ethiopian uplands. In Sennar it receives on its right bank two important tributaries from the Abyssinian heights, the Dinder, a very long and apparently perennial stream, and the Rahad, waterless in the dry season, copious and richly charged with sediment during the rains from June to September. At this period the discharge of the Blue Nile rises from 6000 to 220,000 cubic feet per second, thus greatly exceeding that of the White Nile itself, which is only about 175,000 cubic feet during the floods above the confluence. The economic importance of the Blue Nile as the great fertiliser of Egypt is elsewhere discussed. (NILE; EGYPT.) On the east side of the Abyssinian plateau the chief fluvial basin is that of the Hawash (Awash, Awasi), which rises on the landward side of the coast range, and, like the other large Ethiopian rivers, describes a great semicircular bend on its seaward course between the Shoa uplands and Gallaland. After emerging on the Afar (Danakil) lowlands through a broad breach in the eastern escarpments of the plateau, it is joined on its left bank by its chief affluent, the Germama (Kasam), and then trends round to the north-east in the direction of Tajura Bay. Here the Hawash is a copious stream nearly 200 feet wide and 4 feet deep, even in the dry season, and during the floods rising 50 or 60 feet above low-water mark, thus inundating the plains for many miles along both its banks. Yet it fails at any time to reach the coast, and after a winding course of about 500 miles runs out in the Lake Ausa basin, some 60 or 70 miles from the head of Tajura Bay. This remarkable phenomenon is explained by the position of Ausa in the centre of a saline lacustrine depression, which stands at present several hundred feet below sea-level. Recent surveys give 174 metres for the Assal lakelet near the bay, and several of the other surrounding *badds* (basins) may even be lower, although the Hawash itself still flows at an elevation of 620 metres below its junction with the river Addifuha, where it begins to descend through a chain of badds down to Ausa. While most of the other lagoons are highly saline, with thick incrustations of salt round their margins, Ausa remains fresh throughout the year, owing to the great body of water discharged by the Hawash into this closed basin. Formerly the whole of the Afar and neighbouring Adal (Somali) and Dawari (Galla) territories formed part of the Red Sea, which flooded the now dry rift-valley right up to the foot of the coast range. Another lacustrine region, not however of marine, but perhaps of igneous origin, extends from the Shoa heights southwards to the Samburu depression. In this chain of lovely upland lakes, some fresh, some brackish, some completely closed, others connected by short channels, the chief links in their order from north to south are Zwai, communicating southwards with Hara and Lamina, all in the Arusi Galla territory; then Abai with an outlet to a smaller tarn in the romantic Baroda and Gamo districts, skirted on the west side by grassy slopes and wooded ranges from 6000 to nearly 9000 feet high; lastly, in the Asilli country Count Teleki's Lake Stefanie, the Chuweha of the natives, completely closed and falling to a level of 3700 feet above the sea. To the same system obviously belongs the neighbouring Lake Rudolf (Gallopa or Buzz), which is larger than all the rest put together, and terminates southwards with an active volcano, thus betraying the igneous origin of these basins and bringing them into line with Gregory's "Great Rift Valley." With the determination of the lower course of the Omo, one of the few remaining problems in African geography has been solved. Its upper course had long been identified with the Fintiré, which rises on the northern slope of the Boré heights about 150 miles south-west of Addis-Abbaba, and, after flowing 38 miles north, bends round east and south to the Zighero district, where it takes the name of Omo. It was then supposed either to trend east to the Juba or west to the Sobat until Bottego, on his last disastrous expedition (1896), found that it discharged into the closed basin of Lake Rudolf. Its lower reaches have since been visited by Cavendish, Donaldson Smith, Austin, Wellby, Leontieff, Bulatovich, and others; and the Niamiaa, as it is here called, is now known to be a noble perennial waterway, which is joined along its middle course by the Gojeb, Jibié, Gumi, Kabish, and many other affluents on both its banks, and for some miles above its mouth at the north end of the lake flows in a deep channel varying with the seasons from 50 to 500 feet in width. Throughout its entire length of over 370 miles it has a total fall of about 6000 feet (from 7600 at its source to 1600 at lake-level), and is consequently a very rapid stream, being broken by the Kokoby and other falls, and navigable only for a short distance above its mouth. The Baraka, Shebeyli, Juba, and Sobat, belonging only for short stretches of their upper courses to the Ethiopian region, will be more conveniently described in their principal drainage areas. (NILE; SOMALILAND.)

Climate; flora; fauna.

The vertical disposition of the climatic zones, which is more or less common to all highland regions, and of which Mexico offers a typical example, is somewhat modified on the Ethiopian uplands by the irregular distribution of the rainfall, the varying aspect of the land, and other local conditions. Nevertheless, striking analogies have been observed between the superimposed Mexican and Abyssinian zones, so that it is possible to construct a comparative table of the more salient features, and even of the respective terminologies of each, as under:—

Climatic Zones.			Mean Range of Altitudes.	Mean Range of Temperatures.	Characteristic Flora.
1. (Hot)	Mex.	Tierra Caliente .	0 to 4,000 ft.	77°- 82° F.	Banana, sugar, cocoa-nut, coffee.
	Abys.	Kwalla . .	0 to 5,000 ft.	70°-100° F.	Banana, cotton, date, coffee.
2. (Temp.)	Mex.	Tierra Templada	4000 to 6,000 ft.	62°- 70° F.	Maize, wheat, tobacco, beans.
	Abys.	Voina-dega .	5000 to 8,000 ft.	60°- 80° F.	Wheat, bamboo, terebinth, pulse, citron.
3. (Cold)	Mex.	Tierra Fria .	6000 to 9,000 ft.	58°- 64° F.	Jucca, pine, cedar.
	Abys.	Dega . .	9000 to 14,000 ft.	45°- 60° F.	Pine, barley, oats, scrub.

The correspondence is even closer than appears from this table, because the Mexican scheme excludes Alpine heights, which are included in the Abyssinian dega. Allowance has also to be made for the much lower latitude of the Ethiopian region (4°-16° N.) compared with that of Mexico (16°-32° N.), while the mean altitude of the two plateaux is about the same (7000 feet). Besides the above-mentioned plants, many other tropical forms—indigo, tamarinds, ebony, gummiferous acacias, baobabs—flourish in the Kwalla bottom-lands. Nearly all the European cereals, grasses, and shell fruits are indigenous in the Voina-dega, where are also met the orange, peach, apricot, and other fruit trees, besides the vine, zegba (*Podocarpus*), dhurra, tief, kolkwal (*Euphorbia abyssinica*), juniper, and several species of sycamores, some of which grow to a gigantic size in the sheltered gorges of the intermittent mountain torrents. But in the dega, which includes all the more elevated plains, ambas, and upland valleys, little thrives except the hardier cereals, scrubby plants, and rich grasses affording excellent fodder for cattle, goats, and the long-haired native sheep. The South Ethiopian region between the Hawash and White Nile basins has also its three zones, which, as determined by M. Michel of the Bonchamps Mission (*La Géographie*, July 1900), are:—1. The wide treeless tableland between 6500 and 8500 feet high, covered in places with limestone strata, deeply scored here and there by the running waters. 2. The uplands between the sources of the Hawash and Omo rivers, stretching west to the valley of the Didessa, affluent of the Sobat. Here the ranges, which fall little below 10,000 feet, and are separated by deep valleys, are clothed with low forest, and lower down with scrub which has been partly cleared for cultivation. 3. A low, hilly region from 5000 to 5500 feet high, with scarcely any intervening level ground, but superabundantly watered by streams flowing to the Sobat, and yielding large quantities of coffee and honey. The hitherto almost unknown region stretching still farther south towards Lakes Rudolf and Stefanie proves to be much more elevated, and also more productive, than had been supposed. Alpine heights—one (Guge) nearly 14,000 feet—are spoken of by Bottego, Donaldson Smith, and other explorers near the lakes, and the waterparting between the Omo and Sobat basins, to which Bulatovich has given the name of the *Tsar Nicholas Range*, is surmounted in its northern section by several peaks over 10,000 feet high. This range is lofty enough to intercept the moisture-charged clouds brought by the trade winds from the Indian Ocean, and thus raise the mean rainfall from 30 inches in Abyssinia proper to 40 or 50 inches on the eastern slopes of the Galla uplands. Here have been discovered clear indications of iron and copper, while gold is known to occur in large quantities in the Tumat valley, where it was for some time profitably mined by Mahamet Ali. Gold, iron, and other metals are also mentioned in the Hammer Koki hills north of Lake Stefanie, and recent exploration fully confirms the reports of the early Italian explorers—Massaja, Antinori, Chiarini, Cecchi, and others—regarding the vast superiority of the Galla lands over the Abyssinian plateau in natural resources of all kinds. Weliby, who traversed the lacustrine region between Shoa and Lake Rudolf in 1898-99, describes the "demon-haunted" Walamo district and the Baroda and Game uplands about Lake Abai as "fairy lands," with fertile black and red soils abundantly watered by limpid streams, in parts well timbered or under rich pasturage, and, where cultivated, growing bananas, palms, tobacco, limes, cotton, ginger, raspberries, and *godaris*—"a remarkably good vegetable." Along the banks of the streams "grow big shady trees and a multitude of flowers and undergrowth, alive with birds of bright plumage" (*Geograph. Jour.* September 1900). Whilst extensive woodlands are rarely met with in Abyssinia, except in the Kwalla districts, travellers in the southern uplands speak of the immense forests of conifers, wild olives, and other trees, under the matted moss-grown branches of which they have journeyed for hours together. This home of the coffee-shrub could still supply the world with many other valuable species, such as the *ogguch*, or *korarima*, a fruit much esteemed for its flavour and aroma, and the *kosso*, a beautiful plant with large pendant red flowers, highly prized for its medicinal properties. Besides the elephant, hartebeest, and other large African game, the wild fauna includes the giraffe, rhinoceros, lion, black panther, leopard, hyena, buffalo, gazelles, wild donkeys (striped like a zebra), eagles, vultures, kites, guinea-fowl, partridges, and sand-grouse. Of great economic importance is the civet-cat (*Viverra civetta*), which is domesticated, and yields most of the musk that finds its way to the eastern markets. A more valuable product is coffee, which is indigenous in the Kaffa country, whence it takes its name, and is extensively cultivated throughout the wooded districts of Gallaland. It thrives best on the clearings under the shade of large trees, and is of prime quality; much of the so-called Arabian "mocha" really comes from Ethiopia, and the two sorts are often mixed together for the European markets.

Markets and towns.

Besides gold, ivory, musk, salt, and coffee, the staples of the export trade, many other commodities, such as corn, flour, beer, korarima, honey, wax, cotton, and indigo, are forwarded to the local markets. Of these the busiest are Basso in the north, Bonga in the extreme south, and Lekà in the centre. Liakà, the largest market in Gallaland, stands on the Billò plain near Sopso, and enjoys direct communication with Gojam, Shoa, and other parts of the empire. Bonga, the commercial centre of Kaffa, is much frequented by traders from all the surrounding provinces, and even by foreign merchants following the routes from Zeila and Berbera on the coast through Harrar and the Arusi Galla territory to South Ethiopia. Apart from these market-places there are few permanent centres of population in Abyssinia. Even these are not towns in the strict sense, but military stations, called *katama*, "camps," by the natives, who have no word for town. Since the fall of the great city of Axum, the so-called "capitals" and royal residences—Adua, Gondar, Magdala, and others—have been little more than overgrown villages, flourishing for a time, and then perhaps suddenly abandoned at the whim of the reigning potentate. Menelek himself has successively shifted his headquarters from Ankober, Litché, Debra-Berham, and Entoto, to Addis Abbaba (Addi-Abbas), the present seat of government, both for his kingdom of Shoa and for the empire. This place, which dates only from 1892, stands on the southern slopes of the Entoto range (on which the next preceding capital was situated) on bare, grassy undulations, watered by small streams flowing S.S.E. to the Hawash. The centre of the camp, on which the principal tracks from all directions converge, is the "Gebi," or enclosure of King Menelek, around which straw-thatched native huts, with wattle and mud walls, are scattered in groups over a wide area. The Gebi—which includes the "Elfinage" (Elfig) or two-storeyed dwelling-house, the "aderash" or hall of reception, the "saganat" or clock-bower (used as a hall of justice), and the "guoda" or storehouse—completely covers a small hill overlooking the whole neighbourhood, while around it are the inclosures of the principal nobles. About a mile to the north-east of the palace is the military camp of the king. About thirty miles south of Addis Abbaba can be seen the sacred Mount Zakwala, while to the south-east lie the fine masses of Mount Yarhn, and to the north-west Mount Managasha. On the hills some five miles to the north, 1500 feet above the camp, are the ruins of an old fortress, and the churches of St. Raguel and St. Mariam. The frequent change of capital is due in some measure to the destruction of the forest in the neighbourhood, which in time exhausts the supply of fuel and building materials. These are now obtained from the vicinity of Mount Managasha. The palace of Menelek was placed by Captain Germain and Lieutenant Dyé, of the Marchand Mission, by astronomical observations, in 9° 1′ 4″ N. lat., 38° 42′ 50″ E. long.; but Mr Weld Blundell (*Geogr. Journal*, vol. xv. p. 308, map) places it in 38° 56′ E., which agrees with that assigned in the Italian map by Captain Chaurand (see GLEICHEN, *With the Mission to Menelik*, London, 1898).

In the following list will be found alphabetically arranged all the other important Abyssinian towns regarding which there need be given any information complementary or supplementary to that contained in the 9th edition:—

Addigrat, properly *Add'Igrat*, one of the chief markets in Tigré, east by north of Adua, on a fertile plain about 8000 feet above sea-level, with a permanent population of 1500; to the west is the monastery of *Debra-domo*, one of the most celebrated sanctuaries in Abyssinia. *Adua* (or *Adowa*), capital of Tigré, and one of the largest markets in Ethiopia, with a population of about 3000. It has played a large part in recent political events, and 13 miles S.E. of here was fought the decisive battle of 1st March 1896, in which the Italians were utterly defeated, and had consequently to renounce their claim to a protectorate over Abyssinia. *Aliu-Amba*, a large market in Shoa, the first station beyond Ankober, on the trade route between that place and the Gulf of Aden; has a permanent population of 4000, chiefly Moslem. *Amba-Mariam*, a fortified station in the province of Begbemeder, midway between Gondar and Debra-Tabor near the north-east side of Lake Tsana, with a population of 3000. Here is the famous shrine and church dedicated to St. Mary, whence the name of the place, "Fort St Mary." *Debra-Berham*, "Mountain of Light," a former capital of Shoa, a few miles south of Litché, on the banks of the Beresa, an auriferous head-stream of the Jemma, a tributary of the Blue Nile, with a population of 2500. *Debra-Tabor*, "Mount Tabor," the chief royal residence during the reign of King Johannes, occupies a strong strategic position overlooking the fertile plains east of Lake Tsana, at a height of about 8620 feet above the sea. It has a population of 3000, including the neighbouring station of Samara, headquarters of the Protestant missionaries in the time of King Theodore. *Harrar*, after the withdrawal of the Egyptian garrison, was occupied in 1887 by the Abyssinians with the view of establishing an advanced military and trading station towards the Gulf of Aden. Their claim to the city and surrounding territory has been recognised by international treaties, and here have recently been erected large government buildings in the European style. It is by far the largest town in Abyssinia, with a settled population estimated in 1900 at over 20,000, mostly Mohammedans. Harrar is now a great depot for the distribution of European wares (cottons, silks, cutlery, crockery, beads, &c.) amongst the surrounding Galla and Somali tribes, and throughout the southern provinces of the empire. *Litché* (*Lichek*), till recently the capital of Shoa, and largest market in South Abyssinia, on a terrace watered by a head-stream of the Jemma, a few miles north of Debra-Berham, has a population of 3000. East of this place are the ruins of *Tegulet*, which, after the fall of Axum, was for a time the imperial capital, and gave its name to the present kingdom of Shoa. *Mahdera-Mariam*, "Mary's Rest," for some time a royal residence, and still an important market and great place of pilgrimage in the kingdom of Amhara, a few miles south-west of Debra-Tabor on a head-stream of the Gumera, which flows east to Lake Tsana; its two churches of the "Mother" and the "Son" are amongst the most venerated sanctuaries in the whole of Ethiopia. It has a considerable permanent population estimated at over 4000, Gallas and Amharas, the former mostly Mohammedans. *Sokota*, one of the great central markets, and capital of the province of Wag in Amhara, at the converging point of several main trade routes on the banks of the Bilbis, which flows through the Tsellari to the Takazzé, near the Lasta frontier. The market, which is held three times a week, is numerously attended, especially by dealers in the salt blocks which come from Lake Alalbed, and which are the currency throughout a large part of Ethiopia. In recent years Sokota has suffered much from epidemics, the population falling from about 5000 in 1868 to less than 2000 in 1900.

Roads.

A railway has been projected to run from the French port of Jibuti, Tajura Bay, through Elba in the Harrar district to Addis Abbaba. The coast section was in progress in 1901, and should it ever be completed the whole way, which seems doubtful, Jibuti must become the chief outlet for the rich and varied produce of Gallaland, much of which at present finds its way by the old caravan route through the Arusi territory to the British ports of Zeila, Bulhar, and Berbera, on the Gulf of Aden. This route, followed from time immemorial by the Arussi and Ittu Gallas, is scarcely known to the outer world, and has not yet been followed by any European traveller. It was known, however, to Cecchi, who was informed by the native traders that beyond Harrar it turns sharply round to the west as far as the neighbourhood of Ankober, where it bifurcates, one branch penetrating into Shoa over the Ittu chain, the other turning south-west and reaching South Ethiopia over a pass in the Arussi range. By this trade route Harrar is reached in a month from the remotest confines of Kaffa, and in two or three weeks from the heart of Gallaland, whereas the northern routes through Abyssinia proper to Massawa and Assab are both much longer and far more difficult. The chief distances are:—Massawa by Saati and Asmara to Adua, capital of Tigré, 104 miles; Adua to Sokota, converging point of several trade routes from the coast and the interior, 110; Sokota to the Italian port of Assab, 240; Sokota to Basso, the great market of Gojam, near the Shoa frontier, 190; Basso to Lieká, the great market of Gallaland, 120; Lieká to Bonga, the great market of Kaffa, 115; Bonga to Harrar over the Arussi Range, 270; Harrar to the coast at Zeila and Jibuti, 192 and 130.

Population.

The Ethiopian uplands appear to have been originally peopled by the eastern branch of the Hamitic family, which has occupied this region from the remotest times, and still constitutes the great bulk of its inhabitants. But their domain was encroached upon probably in the Stone Age, but certainly before the historic period, both by the uncultured negroes of the White Nile and by the cultured Himyaritic Semites from South Arabia. The presence of these elements is still conspicuous, especially in North Ethiopia, where the blends between blacks, Hamites, and Semites are so numerous and widespread that the natives, who call themselves *Riopiavian* ("Ethiopians"), are known to the Arabs as *Habashi* ("mixed"),[1] whence our terms "Abyssinia" and "Abyssinians." Throughout historic times the politically dominant people have been the Semitic Himyarites, who, however, have failed to preserve their racial purity, and have gradually been merged in varying proportions with their Hamitic subjects in the present Abyssinian nationality, whose very dark skin, crisp or curly black hair, and some other physical traits, also betray a distinct strain of black blood. The prevailing colour in the central provinces (Amhara, Gojam) is a deep brown, which shades northwards (Tigré, Lasta) to a light olive, and even fair complexion, and southwards (Shoa, Kobbo, Amuru) to a decided chocolate and almost sooty black. Many are distinctly negroid, with tumid lips, small nose, broad at base, and frizzly or ringlety black hair. But the majority may be described as a mixed Hamito Semitic people, who belong unquestionably to the Caucasic division of mankind. Several of the indigenous groups, such as the Khamtas of Lasta, the Agaos of Agaomider ("Agaoland"), the Judaizing Falashas, the Khomants of Dembea, still speak rude dialects of the old Hamitic tongue, whose affinities with the Galla, Somal, Afar, Beja, Egyptian, and Berber have now been established. But the official language and that of all the upper classes is Semitic, derived from the ancient Himyaritic, which is the most archaic member of the Semitic linguistic family. It was introduced with the first immigrants from Yemen; and although no longer spoken, the *Geez*, as it is called, is still studied as the liturgical language of the Abyssinian Christians. Its literature consists of numerous translations of Jewish, Greek, and Arabic works, besides a valuable version of the Bible dating apparently from the 4th century, when Christianity was introduced by Frumentius of Alexandria. Its best modern representative is the Tigriña of Tigré and Lasta, which is much purer but less cultivated than the Amharic dialect, which is current in the central and southern provinces, and much affected by Hamitic elements. All are written in a peculiar syllabic script which, unlike all other Semitic forms, runs from left to right, and is derived from that of the Sabæans and Minæans, still extant in the very old rock inscriptions of South Arabia. The identity has been fully established by the palæographic studies of Bent, Mordtmann, D. H. Müller, and other archæologists. The heterogeneous elements entering into the constitution of the Abyssinians are reflected in their political and social institutions, and especially in their religious beliefs and practices. On a seething mass of African heathendom, already in early times affected by primitive Semitic ideas, was suddenly imposed an undeveloped form of Christianity in the 4th century. While the various ethnical elements have been merged in the composite Abyssinian nation, the primitive and more advanced religious ideas have nowhere been fused in a uniform Christian system. Even the social system is marked by crude notions of justice and absurd "Shamanistic" practices, tempered by a few elevated moral precepts. Foreigners are often surprised at the strange mixture of savagery and lofty notions in a Christian community which, for instance, accounts accidental manslaughter as wilful murder. Dreams, also, are still resorted to for detecting crime. A priest is sent for, and, if his prayers and curses fail, a small boy is drugged, and "whatever person he dreams of is fixed on as the criminal. . . . If he does not dream of the person whom the priest has determined on as the criminal, he is kept under drugs until he does what is required of him" (Count Gleichen, *With the Mission to Menelik*, 1898). Before Menelek's predecessor, Johannes, the Monophysite Abyssinian Church had only one *abuna* (patriarch), always a Copt, and always consecrated by the patriarch of Alexandria. But Johannes raised the number to three, one each for the then vassal states of Gojam and Shoa, and one for his own kingdom of Tigré, with the title of metropolitan. After his death the bishop of Shoa claimed supreme jurisdiction, and to settle the question of supremacy Menelek created two *abunas*, so that the Abyssinian Church boasts of two primates. (See also ABYSSINIAN CHURCH.)

Government.

The Negûs Nagasti is an absolute monarch scarcely controlled in the exercise of unlimited authority even by the *adat* (custom, oral code) respected by most eastern despots. Menelek, whose treatment of his Galla and Somali subjects is well spoken of by Wellby and other travellers, governs his own kingdom of Shoa directly, and the other vassal Abyssinian kingdoms indirectly through their several *ras* ("heads," "chiefs"), all supreme within their respective jurisdictions. The outlying southern provinces are administered by governors who are appointed by the Negûs, and who generally seek the aid of the hereditary local chiefs in maintaining order, levying the irregular forces, and collecting tribute. Under the governors are the *dejazmach* and *kanyazmach* (leaders of right and left wings in the army), and under these the *fit-worari* (literally "rhinoceros-horn," or leaders of the advanced guard), who, like the Boer field-cornets, are expected to lead the tribesmen when summoned to fight. Abyssinia can put 300,000 men into the field, 240,000 of them armed with rifles. The emperor keeps court with a certain barbaric pomp, assisted by the *azaj* (master of ceremonies), *alaka* (lord of the treasury), *muslinis* (receivers of tribute), and other dignitaries.

The Abyssinian *Calendar* is as follows:—The Abyssinian year of 365 days (366 in leap year) begins on the 1st of Máskarram, which corresponds to about our 10th of September. Their months have thirty days each, and are thus named: Máskarram, Tekemt, Hadár, Tahsás, Tarr, Yekátit, Magawit, Miáziah, Genbot, Sanni, Hamle, Nas'hi. The remaining five days in the year, termed Pagmen or Quaggimi (six in leap year—leap day being named Kadis Yohannis), are put in at the end and treated as holidays. The week-days correspond to ours, but are a week behind: *e.g.*, their Easter Sunday is seven days behind ours. Their reckoning is about seven years eight months behind ours: *e.g.*, our New Year's Day 1901 would be about the 21st Tahsás of their 1893, and their New Year's Day 1894 would be about our 10th September 1901.

(A. H. K.)

II. HISTORY.

Since the publication in 1875 of the article on Abyssinia, in the 9th edition of the *Encyclopædia Britannica*, the centre of interest in this country has shifted from the northern to the southern provinces; and several sources of information, not then available, have been opened to us. We make therefore no apology for glancing at the earlier history of Shoa, and bringing up to the date of the British Expedition (1867) a sketch of the internal history both of Northern and Southern Abyssinia before proceeding with the more recent history.

For the last 200 years and more Abyssinia has been a conglomeration of provinces and districts, ill defined, loosely connected, and generally at war with each other. Of these the three chief provinces have been Tigré (northern), Amhara including Gondar (central), and Shoa (southern). The seat of government, or rather of overlordship, has usually been Amhara; the ruler of which, calling himself Negûs Nagasti (king of kings, or emperor), has exacted tribute, when he could, from the other provinces. The question of succession as Negûs Nagasti has been largely dependent on the blood in the veins of the claimant. All the Emperors have based their claims on their direct descent from Solomon and the queen of Sheba; but it is needless to say that in many, if not most, cases their success has been due more to the force of their arms than to the purity of their lineage. Some of the rulers of the larger provinces have at times been given, or given themselves, the title of Negûs or king, so that on occasions as many as three, or even more, Negûses have been reigning at the same time; and this must be borne in mind by the student of Abyssinian history in order to avoid confusion of rulers.

The whole history of the country is one gloomy record of internecine wars, barbaric deeds and unstable governments, of adventurers usurping thrones, only to be themselves unseated, and of raids, rapine, and pillage. Into this chaos enter from time to time broad rays of sunshine, the efforts of a few enlightened monarchs to evolve order from disorder, and to supply to their people the blessings of peace and civilization. Bearing these matters in mind, we find that during the 18th century the most prominent and beneficent rulers were the Emperor Yesu of Gondar, who died about 1720, Sebastié, Negûs of Shoa (1703-18), Amada Yesus of Shoa, who extended his kingdom and founded Ankóber (1743-74), Tekla Giorgis of Amhara (1770-98?) and Asfa Nassen of Shoa (1774-1807), the latter being especially renowned as a wise and benevolent monarch. The first years of the 19th century were disturbed by fierce campaigns between Guxa, Ras of Gondar, and Wolda Selassié, Ras of Tigré, who were both striving for the crown of Guxa's master, the Emperor Eguala Izeion. Wolda Selassié was eventually the victor, and practically ruled the whole country till his death in 1816 at the age of eighty. Mention must here be made of the first British mission, under Lord Valentia and Mr Henry Salt, which was sent in 1805 to conclude an alliance with Abyssinia, and obtain a port on the Red Sea in case France secured Egypt by dividing up the Turkish empire with Russia. This mission was succeeded by many travellers, missionaries, and merchants of all countries, and the stream of Europeans continued until well into Theodore's reign. To Wolda Selassié succeeded Sabagadis of Agamé, by force of arms, and as Ras of Tigré he introduced various Englishmen, whom he much admired, into the country. He improved the prosperity of his land considerably, but by so doing roused the jealousy of Ras Marié of Amhara—to whom he had refused tribute—and Ubié, son of Hailo Mariam, a governor of Simen. In an ensuing battle (in January 1831), both Sabagadis and Marié were killed, and Ubié retired to watch events from his own province. Marié was shortly succeeded in the Ras-ship of Amhara by Ali, a nephew of Guxa and a Mohammedan. But Ubié, who was aiming at the crown, soon attacked Ras Ali, and after several indecisive campaigns proclaimed himself Negûs of Tigré. To him came many French travellers, chief of whom were Lieut. Lefebvre, charged with political and geographical missions, and Captains Galimier and Ferret, who completed for him a useful triangulation and survey of Tigré and Simen (1840-42).

---

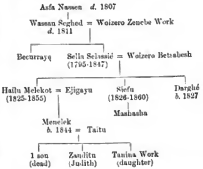
[1] From Arabic root, *habasha*, to collect, gather, mingle. The derivation has been questioned, but on insufficient grounds.

Northern Abyssinia was now divided into two camps, the one, Amhara and Ras Ali, under Protestant British, and the other, Tigré and Ubié, under Roman Catholic French, influence.[1] The latent hostility between the two factions threatened at one time to develop into a religious war, but no serious campaigns took place until Kassa (later Theodore) appeared on the scene. Kassa (*b.* 1818), son of the chief of Kwara, a western district of Amhara, by his talent and energy rapidly came to the front. In consequence of the arrest of his brother Bilawa by Ras Ali, he raised the standard of revolt against the latter, and, collecting a large force, repeatedly beat the troops that were sent against him by the Ras (1841-47). As his power was increasing, to the detriment of both Ras Ali and Ubié, these two princes combined against him, but were heavily defeated by him at Gorgora (on the southern shore of Lake Tsana) in 1853. Ubié retreated to Tigré, and Ras Ali fled to Begemeder, where he eventually died. Kassa now ruled in Amhara, but his ambition was to attain to supreme power, and he turned his attention to conquering the remaining chief divisions of the country, Gojam,[2] Tigré, and Shoa, which still remained unsubdued. Berro, Ras of Gojam, in order to save himself, attempted to combine with Tigré, but his army was intercepted by Kassa and totally destroyed, himself being taken prisoner and executed (May 1854). Shortly afterwards Kassa moved against Tigré, defeated Ubié's forces at Deragié, in Simen (February 1855), took their chief prisoner and proclaimed himself Negûs Nagasti of Ethiopia under the name of Theodore. He now turned his attention to Shoa.

Retracing our steps for a moment in that direction, we find that in 1813 Sahela (or Sella) Selassié, younger son of the preceding Ras Wassan Seghed, had proclaimed himself Negûs or king. His reign was long and beneficent. He restored the towns of Debra Brehan and Angolola, and founded Entoto, the strong stone-built town whose ruins now overlook the modern hut-capital of Addis Abbaba. In the terrible "famine of St Luke" in 1835, Selassié still further won the hearts of his subjects by his wise measures and personal generosity; and by extending his hospitality to Europeans, he brought his country within the closer ken of civilized European Powers. During his reign he received the missions of Major Harris (1841) and M. Rochet d'Héricourt (1843), with both of whom he concluded friendly treaties on behalf of their respective governments. He also wrote to Pope Pius IX., asking that a Roman Catholic bishop should be sent to him. This request was acceded to, and the Pope despatched Monsignor Massaja to Shoa. But before the prelate could reach the country, Selassié was dead (1847), leaving his eldest son, Hailu Melekot, to succeed him. Melekot at once proclaimed himself Negûs, and by sending for Massaja, who had arrived at Gondar, gave rise to the suspicion that he wished to have himself crowned as emperor. By increasing his dominions at the expense of the Gallas, he still further roused the jealousy of the Northerners, and a treaty which he concluded with Ras Ali against Kassa in 1850, determined the latter to crush him at the earliest opportunity.

Thus it was that in 1855 Kassa, under the name of the Emperor Theodore, advanced against Shoa with a large army. Dissensions broke out among the Shoans, and after a desperate and futile attack on Theodore at Debra Brehan, Hailu Melekot died of exhaustion and fever, nominating with his last breath his eleven-year-old son Menelek as successor (November 1855). Darghé, Hailu's brother, took charge of the young prince, but after a hard fight with Angeda, one of Theodore's Rases, was obliged to capitulate. Menelek was handed over to the Negûs, taken to Gondar and there trained in Theodore's service.

The following shows Menelek's descent since the beginning of the 19th century:—



---

[1] For names of Europeans, v. article in *Ency. Brit.*, 9th edition.

[2] South of Amhara.

On the retirement of the Northerners, Siefu, another brother of Hailu, proclaimed himself Negûs of Shoa at Ankóber, and beat the local representatives of Theodore's Government. The emperor returned, however, in 1858, and after several repulses, succeeded in entering Ankóber, where he behaved with great cruelty, murdering or mutilating all the inhabitants. Siefu kept up a gallant defence for two more years, but was then killed by Kebret, one of his own chiefs. Thus chaos again reigned supreme in Shoa. In 1865, Menelek, now a Dejazmach of Tigré, took advantage of Theodore's difficulties with the British Government, and escaped to Workitu, queen of the Wollo Galla country. The emperor, who held as hostage a son of Workitu, threatened to kill the boy unless Menelek were given up; but the gallant queen refused, and lost both her son and her throne. The fugitive meanwhile arrived safely in Shoa, and was there acclaimed as Negûs. For the next three years Menelek devoted himself to strengthening and disciplining his army, to legislation, to building towns, such as Litché (near Dehra Brehan), Worra Hailu (Wollo Galla country), &c., and to repelling the incursions of the Gallas. On the death of Theodore[1] (13th April 1868), many Shoans, including Ras Darghé, were released, and Menelek began to feel himself strong enough, after a few preliminary minor campaigns, to undertake offensive operations against the northern princes. But these projects were of little avail, for another Kassa, an adventurer of Tigré, had by this time (1872) risen to supreme power in the north. With the help of many rifles and guns, presented to him by the British in return for his help in the campaign, he had beaten Ras Bareya of Tigré, Wagshum Gobassié of Amhara, and Tekla Giorgis of Gondar, and after proclaiming himself Negûs Nagasti under the name of Yohannes or John, was now preparing to march on Shoa. Here, however, Menelek was saved from probable destruction through the action of Egypt. This Power had, by the advice of Munzinger, their Swiss governor of Massawa, seized and occupied in 1872 the northern province of Bogos; and, later on, insisted on occupying Hamasen also, for fear Bogos should be attacked. John, after futile protests, collected an army, and with the assistance of Ras Walad Mikael, hereditary chief of Bogos, advanced against the Egyptian forces, who were under the command of one Arendrup, a Dane. Meeting near the Mareb, the Egyptians were beaten in detail, and almost annihilated at Gundet (13th November 1875). An avenging expedition was prepared in the spring of the following year, and, numbering 14,000 men under Ratib Pasha, Loring (American), and Prince Hassan, advanced to Gura and fortified a position in the neighbourhood. Although reinforced by Walad Mikael, who had now quarrelled with John, the Egyptians were a second time (25th March 1876) heavily beaten by the Abyssinians, and retired, losing an enormous quantity of both men and rifles. Colonel Gordon, governor-general of the Sudan, was now ordered to go and make peace with John, but the king had moved south with his army, intending to punish Menelek for having raided Gondar whilst he, John, was engaged with the Egyptians.

Menelek's kingdom was meanwhile torn in twain by serious dissensions which had been instigated by his concubine Bafana. This lady, to whom he was much attached, had been endeavouring to secure the succession of one of her own sons to the throne of Shoa, and had almost succeeded in getting rid of Mashasha, son of Siefu and cousin of Menelek, who was the apparent heir. On the approach of John, the Shoans united for a time against their common enemy. But after a few skirmishes they melted away, and Menelek was obliged to submit and do obeisance to John. The latter behaved with much generosity, but at the same time imposed terms which effectually deprived Shoa of her independence (March 1878). In 1879 Gordon was sent on a fresh mission to John on behalf of Egypt; but he was treated with scant courtesy, and was obliged to leave the country without achieving anything permanent.

The Italians now come on the scene. Assab, a port near the southern entrance of the Red Sea, had been bought from the local Sultan in 1869 by an Italian company, which, after acquiring more land in 1879 and 1880, was bought out by the Italian Government in 1882. In this year Count Antonelli was despatched to Shoa in order to improve the prospects of the colony by treaties with Menelek and the Sultan of Aussa. Several missions followed upon this one, with more or less successful results; but both John and Menelek became uneasy when Beilul was occupied by the Italians in January 1885, and Massawa taken over by them from Egypt in the following month. This latter act was greatly resented by the Abyssinians, for by a treaty concluded with a British and Egyptian mission under Admiral Hewett and Mason Pasha[2] in the previous year, free transit of goods was to be allowed through this port. Matters came to a head in January 1887, when the Abyssinians, in consequence of a refusal from General Gene to withdraw his troops from Waa and Tula, surrounded and massacred 400 Italian troops at Dogali. Reinforcements were sent from Italy, whilst in the autumn the British Government stepped in and tried to mediate by means of a mission under Mr (afterwards Sir Gerald) Portal. His mission, however, proved abortive, and after many difficulties and dangers he returned to Egypt at the end of the year. In April 1888, the Italian forces, numbering over 20,000 men, came into touch with the Abyssinian army; but negotiations took the place of fighting, with the result that both forces retired, the Italians only leaving some 5000 troops in Eritrea, as their colony was now called. Meanwhile John had not been idle with regard to the Dervishes. Although he had set his troops in motion too late to relieve Kassala, Ras Alula, his chief general, had succeeded in inflicting a handsome defeat on Osman Digna at Amideb in July 1887. A large force of Dervishes had, however, entered and sacked Gondar in April 1887, and to avenge this John took the field in force against the enemy, who were still harassing the north-west of his territory. A great battle ensued at Gallabat, in which the Dervishes, under Zeki Tumal, were at first beaten. But a stray bullet pierced John's heart, and his men fled, leaving camp and stores, besides the body of their emperor, in the hands of the enemy (9th March 1889).

Immediately the news reached Menelek he proclaimed himself emperor, and received the submission of Gondar, Gojam, and several other provinces. In common with other northern princes, Mangasha, reputed son and heir of King John, and Ras Alula, refused to acknowledge the sovereignty of Menelek, but on the latter marching against them in the following January with a large army, they submitted. As it happened, Count Antonelli was with Menelek when he claimed the throne, and promptly concluded with him on behalf of Italy a friendly treaty, to be known hereafter as the famous Ucciali treaty. In consequence of this the Italians occupied Asmara, made friends with Mangasha, and received Ras Makunnen,[3]

---

[1] For details of Theodore's life and the British expedition, v. *Ency. Brit.*, 9th edition.

[2] The main object of this mission was to seek John's assistance in evacuating the Egyptian garrisons in the Sudan, which were threatened by the Dervishes.

[3] Ras of Harrar, which province had been conquered and occupied by Menelek in January 1887.

Menelek's nephew, as his plenipotentiary in Italy. Thus it seemed as though hostilities between the two countries had come to a definite end, and that peace was assured in the land. For the next three years the land was fairly quiet, the chief political events being the convention (6th February 1891) between Italy and Abyssinia, protocols between Italy and Great Britain (24th March and 15th April 1891), and a proclamation by Menelek (10th April 1891), all on the subject of boundaries. As, however, the Italians became more and more friendly with Mangasha and Tigré the apprehensions of Menelek increased, till at last, in February 1893, he wrote denouncing the Uccialli treaty, which differed in the Italian and Amharic versions. According to the former, the Negûs was bound to make use of Italy as a channel for communicating with other Powers, whereas the Amharic version left it optional. Meanwhile the Dervishes were threatening Eritrea. A fine action by Colonel Arimondi gained Agordat for Italy (21st December 1893), and a brilliant march by Colonel Baratieri resulted in the acquisition of Kassala (17th July 1894). But on his return Baratieri found that Mangasha was intriguing with the Dervishes, and had actually crossed the frontier with a large army. At Koatit and Senafe (13th to 15th January 1895) Mangasha was met and heavily defeated by Baratieri, who occupied Adigrat in March. But as the year wore on the Italian commander pushed his forces unsupported too far to the south. Menelek was advancing with a large army in national support of Mangasha, and the subsequent reverses at Amba Alagi (7th December 1895) and Makalle (23rd January 1896) forced the Italians to fall back.

Reinforcements of many thousands were meanwhile arriving at Massawa, and in February Baratieri took the field at the head of over 13,000 men. Menelek's army, amounting to about 90,000, had during this time advanced, and was occupying a strong position at Abba Garima, near Adua. Here Baratieri attacked him on the 1st March, but the difficulties of the country were great, and one of the four Italian brigades had pushed too far forward. This brigade was attacked by overwhelming numbers, and on the remaining brigades advancing in support, they were successively cut to pieces by the encircling masses of the enemy. The Italians lost nearly 4000 killed and wounded and 2000 prisoners, whilst the Abyssinians owned to a loss of over 3000. General Baldissera advanced with a large body of reinforcements to avenge this defeat, but the Abyssinians, desperately short of supplies, had already retired, and beyond the peaceful relief of Adigrat no further operations took place. It may here be remarked that the white prisoners taken by Menelek were exceedingly well treated by him, and that he behaved throughout, as he has ever since, with the greatest humanity and dignity. A peace was signed at Addis Abbaba in the following October, and negotiations on the question of frontiers were commenced, which were only brought to a conclusion in the autumn of 1900.

This war, so disastrous to Italy, attracted the attention of all Europe to Abyssinia and its monarch, and numerous missions, two Russian, three French, and one British, were despatched to the country and hospitably received by Menelek. The British one, under Mr (now Sir) Rennell Rodd, concluded a friendly treaty with Abyssinia (15th May 1897), but did not, except in the direction of Somaliland, touch on frontier questions, which still form a subject of discussion. During the same year a small French expedition under Messrs Clochette and De Bonchamps endeavoured to reach the Nile, but, after surmounting many difficulties, stuck in the marshes of the Upper Sobat and was obliged to return. Another expedition of Abyssinians, under Dejaj Tasamma, and accompanied by three Europeans—a Frenchman, a Swiss, and a Russian—started early in 1898, and reached the Nile at the Sobat mouth in June, a few days only before Major Marchand and his gallant companions arrived on the scene. But no contact was made, and the expedition returned to Abyssinia. In the same year (1898) Menelek proceeded northwards with a large army, for the purpose of chastising Mangasha, who was again rebelling against his authority. After some trifling fighting Mangasha submitted, and Ras Makunnen despatched a force to subdue Beni Shangul, the chief of which gold country, Wad Tur el Guri, was showing signs of disaffection. This effected, the Abyssinians almost came into contact with the Egyptian troops sent up the Blue Nile (after the occupation of Khartum) to Famaka and towards Gallabat. But as both sides were anxious to avoid a collision, no hostile results ensued, and matters remain on a friendly footing between the nations. Negotiations and surveys on the subject of frontiers were in progress, and were likely to be brought to a successful conclusion, in 1901.

Since 1897 British influence in Abyssinia, owing largely, no doubt, to the conquest of the Sudan, the destruction of the Dervish power, and the result of the Fashoda incident, has been sensibly on the increase. But it remains to be seen whether any European influence will be of much avail after the demise of the present enlightened emperor, or whether Abyssinia will relapse into the state of anarchy and desolation which has characterized so much of her history.

AUTHORITIES.—BENT, THEODORE. *The Sacred City of the Ethiopians.* London, 1893.—BLANDFORD, W. T. *The Geology and Zoology of Abyssinia.* London, 1870.—BLUNDELL, H. W. "A Journey through Abyssinia," *Geograph. Jour.* vol. xv. 1900.—BORELLI, JULES. *Ethiopie Méridionale.* Paris, 1900.—FUMAGALLI, G. *Bibliografia Etiopica.* Milan, 1893.—GLEICHEN, Count. *With the Mission to Menelik.* London, 1898.—KELTIE, J. S. *The Partition of Africa.* London, 1895.—KEANE, A. H. *Man: Past and Present,* 2nd ed. Cambridge, 1901.—LAURIBAR, P. de. *Douze Ans en Abyssinie.* Paris, 1898.—PORTAL, G. H. *My Mission to Abyssinia.* London, 1892.—RECLUS, E. *Universal Geography,* vol. x.—VANDERHEYM, J. G. *Une Expédition avec le Negous Ménélik.* Paris, 1896.—VIGNÉRAS, S. *Une Mission Française en Abyssinie.* Paris, 1897.—WELLBY, Capt. M. S. "King Menelek's Dominions," &c., *Geograph. Jour.* September 1900.—MASSAJA, Cardinal. *I miei 35 anni di Missione nell' alta Etiopia,* 10 vols. Milan, 1886-93.—CECCHI. *Da Zeila alle Frontiere del Caffa,* Rome, 1887; and *L'Abissinia Settentrionale,* Milan, 1888.—J. SPILLMANN. *Abessinien und seine Bedeutung für unsere Zeit,* &c. Freiburg in Breisgau, 1892.—SAPETO. *Etiopia.* Rome, 1890.

(O.*)

Abyssinian Church.—As the chronicle of Axum relates, Christianity was adopted in Abyssinia in the 4th century. About 330 A.D. Frumentius was made first Bishop of Ethiopia by Athanasius, patriarch of Alexandria. Cedrenus and Nicephorus err in dating Abyssinian Christianity from Justinian c. 542. From Frumentius to the present day, with one break, the Metropolitan has always been appointed from Egypt, and, oddly enough, he is always a foreigner. Little is known of church history down to the period of Jesuit rule, which broke the connexion with Egypt from about 1500 to 1633. But the Abyssinians rejected the Council of Chalcedon, and still remain monophysites. Union with the Coptic Church (*q.v.*) continued after the Arab conquest in Egypt. Abû Sâlih records (12th century) that the patriarch used always to send letters twice a-year to the kings of Abyssinia and Nubia, till Al Hâkim stopped the practice. Cyril, 67th patriarch, sent Severus as bishop, with orders to put down polygamy, and to enforce observance of canonical consecration for all churches. These examples show the close relations of the two churches in the Middle Ages. But late in the 15th century, the church was taken captive by a Portuguese mission. In 1439 an Abyssinian embassy to Rome had resulted in the despatch of a mission under Alvarez. Later, Ignatius Loyola wished to essay the task of conversion, but was forbidden. Instead, the Pope sent out Barret as patriarch of the East Indies, with Oviedo as bishop; and from Goa envoys went to Abyssinia, followed by Oviedo himself, to secure the king's adherence to Rome. After repeated failures some measure of success was achieved, but not till 1604 did the king make formal submission to the Pope. Then the people rebelled and the king was slain. Fresh Jesuit victories were followed sooner or later by fresh revolt, and Roman rule hardly triumphed, when once for all it was overthrown. In 1633 the Jesuits were expelled and allegiance to Alexandria resumed.

There are many early rock-cut churches in Abyssinia, closely resembling the Coptic. After these, two main types of architecture are found—one basilican, the other native. The cathedral at Axum is basilican, though the early basilicas are nearly all in ruins—*e.g.*, that at Adulis and that of Martula Mariam in Gojam, rebuilt in the 16th century, on the ancient foundations. These examples show the influence of those architects who, in the 6th century, built the splendid basilicas at Sanâ and elsewhere in Arabia. Of native churches there are two forms—one square or oblong, found in Tigré; the other circular, found in Amhara and Shoa. In both, the sanctuary is square and stands clear in the centre. An outer court, circular or rectangular, surrounds the body of the church. The square type may be due to basilican influence, the circular is a mere adaptation of the native hut: in both, the arrangements are obviously based on Jewish tradition. Church and outer court are usually thatched, with wattled or mud-built walls adorned with rude frescoes. The altar is a board on four wooden pillars having upon it a small slab (tabût) of alabaster, marble, or shittim wood, which forms its essential part. At Martula Mariam, the wooden altar overlaid with gold had two slabs of solid gold, one 300, the other 800 ounces in weight. The ark kept at Axum is described as 2 feet high, covered with gold and gems. The liturgy was celebrated on it in the king's palace at Christmas, Epiphany, Easter, and Feast of the Cross.

Generally the Abyssinians agree with the Copts in ritual and practice. The LXX. version was translated into Geez, the literary language, which is used for all services, though hardly understood. Saints and angels are highly revered, if not adored, but graven images are forbidden. Fasts are long and rigid. Confession and absolution, strictly enforced, give great power to the priesthood. The clergy must marry, but once only. Pilgrimage to Jerusalem is a religious duty and covers many sins. (See also under ABYSSINIA.)

AUTHORITIES.—TELLEZ. *Historia de Ethiopia.* Coimbra, 1660. —ALVAREZ. Trans. by Lord Stanley of Alderley. London, 1880. — LUDOLPHUS. *History of Ethiopia*, London, 1684, and other works. —T. WRIGHT. *Christianity of Arabia.* London, 1855.—C. T. BEKE. "Christianity among the Gallas," *Brit. Mag.* London, 1847.—J. C. HOTTEN. *Abyssinia Described.* London, 1868.— "Abyssinian Church Architecture." *Royal. Inst. Brit. Arch. Transactions*, 1869. *Ibid. Journal*, March 1897.—*Archæologia*, vol. xxxii.

(A. J. B.)

Academy, French.—The history of the French Academy has continued its tranquil course since 1875, marked perhaps in later years by a greater desire to respond to the purely literary dictates of its composite conscience. Its elections, under the Republic, have been social functions of a highly fashionable character. One alteration in its methods has to be chronicled: in 1869 it became the custom to discuss the claims of the candidates at a preliminary meeting of the members. In 1880, on the instance of the philosopher Caro, supported by A. Dumas fils, and by the aged Désiré Nisard, it was decided to abandon this method, which led to great inconvenience in practice. A point upon which much stress is often laid, and regarding which the most inaccurate statements are put forth, is the degree in which, since its foundation, the French Academy has or has not represented the best literary life of France. On this subject it may be well to supply some supplementary information. It appears from an examination of the lists of members that a surprising number of authors of the highest excellence have, from one cause or another, escaped the honour of academic "immortality." When the Academy was founded in 1634, the moment was not a very brilliant one in French letters. Among the forty original members we find only ten who are remembered in literary history; of these there are four who may reasonably be considered famous still—Balzac, Chapelain, Racan, and Voiture. In that generation Scarron was never one of the forty, nor do the names of Descartes, Malebranche, or Pascal occur; it must not be supposed that any lack of honour was intended to these philosophers, but the French Academy had not come to consider its doors open to this class of writers. The duke of Rochefoucauld declined the honour from a proud modesty, and Rotron died too soon to be elected. The one astounding omission of the 17th century, however, is the name of Molière, who was excluded by his profession as an actor. On the other hand, the French Academy was never more thoroughly representative of letters than when Boileau, Corneille, La Fontaine, Racine, and Quinault were all members of its body. Of the great theologians of that and the subsequent age, the Academy contained Bossuet, Fléchier, Fénelon, and Massillon, but not Bourdaloue. La Bruyère and Fontenelle were among the forty, but not Saint-Simon, whose claims as a man of letters were unknown to his contemporaries. Early in the 18th century almost every literary personage of eminence found his place naturally in the Academy. The only exceptions of importance were Vauvenargues, who died too early for the honour, and two men of genius of dubious social position, Lesage and the Abbé Prévost d'Exiles. As the Revolution approached, the *personnel* of the Academy became greatly disturbed. Montesquieu and Voltaire belonged to it, but not Rousseau or Beaumarchais. Of the Encyclopædists, the French Academy opened its doors to D'Alembert, Condorcet, Volney, Marmontel, and La Harpe, but not to Diderot, Rollin, Condillac, Helvetius, or the Baron d'Holbach. It is to be supposed that the claims of Turgot and of Quesnay did not appear to the Academy sufficiently literary, since neither was elected. In the transitional period, when the social life of Paris was distracted and the French Academy provisionally closed, neither André Chénier nor Benjamin Constant, nor Joseph de Maistre became enrolled among its members. In the early years of the 19th century considerations of various kinds excluded from the ranks of the forty the dissimilar names of Lamennais, Prudhon, Comte, and Béranger. Critics of the French Academy are fond of pointing out that neither Stendhal, nor Balzac, nor Théophile Gautier, nor Flaubert, penetrated into the Mazarine Palace. It is not so often remembered that writers so academic as Thierry, and Michelet, and Quinet, suffered the same exclusion. In later times neither Alphonse Daudet nor Edmond de Goncourt, Guy de

Maupassant nor Ferdinand Fabre, has been among the forty immortals. The non-election, after a long life of distinction, of the scholar Fustel de Coulanges, is less easy to account for. Verlaine, although a man of great genius, was an example of the kind of person no academy can ever be expected to recognize. Of the degree in which the French Academy represented the highest literary ability during the last quarter of the 19th century, an examination of the following facts will offer evidence. Of the forty members who composed its body at the close of 1875 only three were still alive in the summer of 1901. These were M. Ernest Legouvé, who was elected so long ago as 1855; M. Emile Ollivier, elected on the 7th of April 1870, but, in consequence of the intractability of his political opinions, never formally received; and M. Mézières, elected in 1874. The first death to occur in the Academy was that of Patin; he was succeeded in June 1876 by the distinguished Latinist, M. Gaston Boissier. To succeed the poet Autran, M. Victorien Sardou was elected on the 7th of June 1877; his success was hotly contested by the duke of Audiffret-Pasquier, and one vote transferred would have annulled the election. In 1878, at the death of Thiers, his seat was taken by Henri Martin, that of Bernard by Ernest Renan, and that of Loménie by Taine. In December of that year, at the death of Dupanloup, no opposition was offered to the duke of Audiffret-Pasquier, although he was in the unique position of having never published anything of a literary character. For two years there was no change in the composition of the French Academy, but in 1880 several new names were added; Maxime du Camp succeeded to Saint-René Taillandier, Labiche to Sacy, and M. Rousse to Jules Favre. In 1881 the absence of the younger poets from the Academy, which had been much commented on, was reformed by the election of M. Sully-Prudhomme in the place of Duvergier de Hauranne. In the same year Pasteur followed Littré, and Cherbuliez Dufaure. At the death of the poet Barbier, Perrand, bishop of Autun, was unanimously elected in 1882; later on in the same year Pailleron replaced Charles Blanc and Mazade Champagny. At the death of Sandeau, the popular writer, Edmond About, was elected to take his place, but died (January 1885) too soon to be received. The elections in the latter part of 1884 were more numerous than they had been, in a similar period, within the memory of man. M. Coppée had been admitted in February to take the place of the poet Laprade. The winter elections of 1884 included Lesseps in the room of Martin, Duruy in that of Mignet, Bertrand in that of J. B. Dumas, and M. Halévy in that of the count of Haussonville. After this extraordinary influx the Academy was for some time at rest, but in 1886 four *fauteuils* had to be filled; that of About was taken by Léon Say; that of Victor Hugo (at his expressed wish) by Leconte de Lisle; that of the duke of Noailles by Edouard Hervé; and that of the count of Falloux by M. Gréard. The philosopher Caro having died (July 1887), he was replaced by the historian, Count Othenin of Haussonville in 1888. The most aged member of the Academy, Viel-Castel, who had been born in 1800, died 4th Oct. 1887, and was succeeded by Admiral Jurien de la Gravière; Labiche (d. Jan. 1888) was succeeded by Meilhac; and Désiré Nisard (d. 25th March 1888) by the Viscount Melchior de Vogüé, all these in 1888. Augier, the playwright, dying on 25th October 1889, his *fauteuil* was filled by M. de Freycinet, after a prolonged struggle (11th December 1890). Octave Feuillet dying (28th December 1890), three novelists contended for his seat—Emile Zola, Ferdinand Fabre, and Pierre Loti. At the first voting M. Zola stood at the top of the poll, at the sixth scrutiny Pierre Loti was declared elected. M. Ernest Lavisse, the historian, succeeded Admiral de la Gravière in 1892. In 1893, after the death of Xavier Marmier, Viscount Henri de Bornier, the poet, who had been a constant applicant for several years, was at length elected by a large majority. M. Thureau-Dangin on the same day succeeded Rousset; in March Challemel-Lacour followed Renan (died October 1892); and in June M. Brunetière the critic, the journalist John Lemoinne. It proved impossible for the Academy to come to any understanding about the *fauteuil* of Taine (who died March 1893), and the election was therefore postponed. In the meantime Mazade died, and was replaced by the poet Heredia, in February 1894. Finally, after what seemed an endless struggle, the historian, M. Albert Sorel, secured in May 1894 the vacant *fauteuil* of Taine; and M. Paul Bourget was elected on the same day to succeed Du Camp. Later elections to the French Academy have been as follows: in 1894, M. Henry Houssaye; in 1895, M. Jules Lemaître; in 1896, MM. Anatole France, the Marquis Costa de Beauregard, Gaston Paris, André Theuriet, and Albert Vandal; in 1897, the count de Mun and M. Gabriel Hanotaux; in 1898, the sculptor M. Eugène Guillaume, and the farce-writer M. Henri Lavedan; in 1899, the politician M. Paul Deschanel; in 1900, the novelist M. Paul Hervieu and the critic M. Emile Faguet, both elected on the 15th of February, and on the 28th of June, M. Berthelot; in 1901, the Marquis de Vogüé, the archæologist, and M. Edmond Rostand, the poet and dramatist, both on 30th May.

(E. G.)

Academy, Royal.—The Royal Academy of Arts in London, to give it the original title in full, was founded in 1768, "for the purpose of cultivating and improving the arts of painting, sculpture, and architecture." Many attempts had previously been made in England to form a society which should have for its object the advancement of the fine arts. Sir James Thornhill, his son-in-law Hogarth, the Dilettanti Society, made efforts in this direction, but their schemes were wrecked by want of means. Accident solved the problem. The crowds that attended an exhibition of pictures held in 1758 at the Foundling Hospital for the benefit of that charity, suggested a way of making money hitherto unsuspected. Two societies were quickly formed, one calling itself the "Society of Artists," and the other the "Free Society of Artists." The latter ceased to exist in 1774. The former flourished, and in 1765 was granted a royal charter under the title of the "Incorporated Society of Artists of Great Britain." But though prosperous it was not united. A number of the members, including the most eminent artists of the day, resigned in 1768, and headed by William Chambers, the architect, and Benjamin West, presented on 28th November in that year to George III., who had already shown his interest in the fine arts, a memorial soliciting his "gracious assistance, patronage and protection," in "establishing a society for promoting the arts of design." The memorialists stated that the two principal objects they had in view were the establishing of "a well-regulated school or academy of design for the use of students in the arts, and an annual exhibition open to all artists of distinguished merit; the profit arising from the last of these institutions" would, they thought, "fully answer all the expenses of the first," and, indeed, leave something over to be distributed "in useful charities." The king expressed his agreement with the proposal, but asked for further particulars. These were furnished to him on 7th December and approved, and on 10th December they were submitted in form, and the document embodying them received his signature, with the words "I approve of this plan; let it be put into execution." This document, known as the "Instrument," defined under twenty-seven heads the constitution and government of the Royal Academy, and contained the names of the thirty-six original members nominated by the king. Changes and modifications in the laws and regulations laid down in it have of course been made, but none of them without the sanction of the sovereign, and the "Instrument" remains to this day in all essential particulars the Magna Charta of the society. Four days after the signing of this document—on 14th December—twenty-eight of the first nominated members met and drew up the Form of Obligation which is still signed by every academician on receiving his diploma, and also elected a president, keeper, secretary, council, and visitors in the schools; the professors being chosen at a further meeting held on the 17th. No time was lost in establishing the schools, and on 2nd January 1769 they were opened at some rooms in Pall Mall, a little eastward of the site now occupied by the Junior United Service Club, the president, Sir Joshua Reynolds, delivering on that occasion the first of his famous "discourses." The opening of the first exhibition at the same place followed on 26th April.

The king when founding the Academy undertook to supply out of his own privy purse any deficiencies between the receipts derived from the exhibitions and the expenditure incurred on the schools, charitable donations for artists, &c. For twelve years he was called upon to do so, and contributed in all something over £5000, but in 1781 there was a surplus, and no further call has ever been made on the royal purse. George III. also gave the Academy rooms in what was then his own palace of Somerset House, and the schools and offices were removed there in 1771, but the exhibition continued to be held in Pall Mall, till the completion in 1780 of the new Somerset House, when the Academy took possession of the apartments in it which the king, on giving up the palace for Government offices, had expressly stipulated should be provided. Here it remained till 1837, when the Government, requiring the use of these rooms, offered in exchange a portion of the National Gallery, then just erected in Trafalgar Square. The offer, which contained no conditions, was accepted. But it was not long before the necessity for a further removal became imminent. Already in 1850 notice was given by the Government that the rooms occupied by the Academy would be required for the purposes of the National Gallery, and that they proposed to give the Academy £40,000 to provide themselves with a building elsewhere. The matter slumbered, however, till 1858, when the question was raised in the House of Commons as to whether it would not be justifiable to turn the Academy out of the National Gallery without making any provision for it elsewhere. Much discussion followed, and a royal commission was appointed in 1863 "to inquire into the present position of the Royal Academy in relation to the fine arts, and into the circumstances and conditions under which it occupies a portion of the National Gallery, &c." In their report, which contained a large number of proposals and suggestions, some of them since carried out, the commissioners stated that they had "come to the clear conclusion that the Royal Academy have no legal, but that they have a moral claim to apartments at the public expense." Negotiations had been already going on between the Government and the Academy for the appropriation to the latter of a portion of the site occupied by the recently purchased Burlington House, on which the Academy offered to erect suitable buildings at its own expense. The negotiations were renewed in 1866, and in March in the following year a lease of old Burlington House, and of a portion of the garden behind it, was granted to the Academy for 999 years at a peppercorn rent, subject to the condition that "the premises shall be at all times exclusively devoted to the purpose of the cultivation of the fine arts." The Academy immediately proceeded to erect, on the garden portion of the site thus acquired, exhibition galleries and schools, which were opened in 1869, further additions being made in 1884. An upper storey was also added to old Burlington House, in which to place the diploma works, the Gibson statuary, and other works of art. Altogether the Academy, out of its accumulated savings, has spent on these buildings more than £160,000. They are its own property, and are maintained entirely at its expense.

The government of the Academy was by the "Instrument" vested in "a president and eight other persons, who shall form a council." Four of these were to retire every year, and the seats were to go by rotation to every academician. The number was increased in 1870 to twelve, and reduced to ten in 1875. The rules as to retirement and rotation are still in force. Newly-elected academicians begin their two years' service as soon as they have received their diploma. The council has, to quote the "Instrument," "the entire direction and management of the business" of the Academy in all its branches; and also the framing of new laws and regulations, but the latter, before coming into force, must be sanctioned by the general assembly and approved by the Sovereign. The general assembly consists of the whole body of academicians, and meets on certain fixed dates and at such other times as the business may require; also at the request to the president of any five members. The principal executive officers of the Academy are the president, the keeper, the treasurer, the librarian, and the secretary, all now elected by the general assembly, subject to the approval of the Sovereign. The president is elected annually on the foundation day, 10th December, but the appointment is virtually for life. No change has ever been made in the conditions attached to this office, with the exception of its being now a salaried instead of an unsalaried post. The treasurership and librarianship, both offices originally held not by election but by direct appointment from the Sovereign, are now elective, the holders being subject to re-election every five years, and the keepership is also held upon the same terms; while the secretaryship, which up to 1873 had always been filled like the other offices by an academician, has since then been held by a layman. Other officers elected by the general assembly are the auditors (three academicians, one of whom retires every year), the visitors in the schools (academicians and associates); and the professors of painting, sculpture, and architecture—who must be members—and of anatomy and chemistry. There are also a registrar, and curators and teachers in the schools, who are appointed by the council.

The thirty-six original academicians were named by George III. Their successors have been elected, up to 1867, by academicians only—since that date by academicians and associates together. The original number was fixed in the "Instrument" at forty, and has so remained. Each academician on his election has to present an approved specimen of his work—called his diploma work—before his diploma is submitted to the Sovereign for signature. On receiving his diploma he signs the Roll of Institution as an academician, and takes his seat in the general assembly. The class of associates, out of whom alone the academicians can be elected, was founded in 1769—they were "to be elected from amongst the exhibitors, and be entitled to every advantage enjoyed by the royal academicians, excepting that of having a voice in the deliberations or any share in the government of the Academy." Those exhibitors who wished to become candidates had to give in their names at the close of the exhibition. This condition no longer exists, candidates having since 1867 merely to be proposed and seconded by members of the Academy. On election, they attend at a council meeting to sign the Roll of Institution as an associate, and receive a diploma signed by the president and secretary. In 1867 also associates were admitted to vote at all elections of members; in 1868 they were made eligible to serve as visitors in the schools; and in 1886 to become candidates for the professorships of painting, sculpture, and architecture. At first the number of associates was limited to twenty; in 1866 the number was made indefinite with a minimum of twenty, and in 1876 the minimum was raised to thirty. Vacancies in the lists of academicians and associates caused by death or resignation can be filled up at any time within five weeks of the event, except in the months of August, September, and October, but a vacancy in the associate list caused by election only dates from the day on which the new academician receives his diploma. The mode of election is the same in both cases, first by marked lists and afterwards by ballot. All who at the first marking have four or more votes are marked for again, and the two highest then go to the ballot. Engravers have always constituted a separate class, and up to 1855 they were admitted to the associateship only, the number, six, being in addition to the other associates; now the maximum is four, of whom not more than two may be academicians. A class of honorary retired academicians was established in 1862, and of honorary retired associates in 1884. The first honorary foreign academicians were elected in 1869. The honorary members consist of a chaplain, an antiquary, a secretary for foreign correspondence, and professors of ancient history and ancient literature. These posts, which date from the foundation of the Academy, have always been held by distinguished men.

Schools.—One of the most important functions of the Royal Academy, and one which for nearly a century it discharged alone, was the instruction of students in art. The first act, as has been shown, of the newly-founded Academy was to establish schools—"an Antique Academy" and a "School for the Living Model" for painters, sculptors, and architects. In the first year, 1769, no fewer than seventy-seven students entered. A school of painting was added in 1815, and special schools of sculpture and architecture in 1871. It would occupy too much space to follow the various changes that have been made in the schools since their establishment. In one important respect, however, they remain the same, viz., in the instruction being gratuitous—no fees have ever been charged. Up to the removal of the Academy to its present quarters the schools could not be kept permanently open, as the rooms occupied by them were wanted for the exhibition. They are now open all the year round with the exception of a fortnight at Christmas, and the months of August and September. They consist of an antique school, upper and lower schools of painting, a school of drawing from the life, a school of modelling from the life, and an architectural school. Admission is gained by submitting certain specimens of drawing or modelling, and the successful candidates, called probationers, have then to undergo a further test in the schools, on passing which they are admitted as students for three years. At the end of that time they are again examined, and if qualified admitted for a further term of two years. These examinations are held twice a year, in January and July. Female students were first admitted in 1860. There are many scholarships, money prizes, and medals to be gained by the various classes of students during the time of studentship, including travelling studentships of the value of £200 for one year, gold and silver medals, and prizes varying from £50 to £10. There are permanent curators and teachers in all the schools, but the principal teaching is done by the visitors, academicians, and associates, elected to serve in each school. The average cost of maintaining these schools, including salaries, fees, cost of models, prizes, books, maintenance of building, &c., has been for the last thirty years from £5000 to £6000 a year. This sum does not include the cost of certain scholarships and prizes derived from moneys given or bequeathed for this purpose, such as the Landseer scholarships, the Creswick prize, the Armitage prizes, and the Turner scholarship and gold medal.

Charities.—Another of the principal objects to which the profits of the Royal Academy have been devoted has been the relief of distressed artists and their families. From the commencement of the institution a fund was set apart for this purpose, and subsequently a further sum was allotted to provide pensions for necessitous members of the Academy and their widows. Both these funds were afterwards merged in the general fund, and various changes have from time to time been made in the conditions under which pensions and donations have been granted and in their amount. At the present time pensions not exceeding a certain fixed amount may be given to academicians and associates, sixty years of age, who have retired and whose circumstances show them to be in need, provided the sum given does not make their total annual income exceed a certain limit, and the same amounts can be given to their widows subject to the same conditions. No pensions are granted without very strict inquiry into the circumstances of the applicant, who is obliged to make a yearly declaration as to his or her income. The average annual amount of these pensions has been latterly about £2000. Pensions are also given according to the civil service scale to certain officers on retirement. It may be stated here that with the exception of these pensions and of salaries and fees for official services, no member of the Academy derives any pecuniary benefit from the funds of the institution. Donations to distressed artists who are or have been exhibitors at the Royal Academy, their widows and children under twenty-one years of age, are made twice a year in February and August. The maximum amount that can be granted to any one applicant in one donation is £100, and no one can receive a grant more than once a year. The average yearly amount thus expended is from £1200 to £1500. In addition to these charities from its general funds, the Academy administers for the benefit of artists, not members of the Academy, certain other funds which have been bequeathed to it for charitable purposes, viz., the Turner fund, the Cousins fund, the Cooke fund, the Newton bequest, and the Edwards fund (*see* below).

Exhibitions.—The source from which have been derived the funds for carrying on the varied work of the Royal Academy, its schools, its charities, and general cost of administration, and which has enabled it to spend large sums on building, and provided it with the means of maintaining the buildings, has been the annual exhibitions. With the exception of the money left by John Gibson, R.A., some of which was spent in building the gallery containing the statues and bas-reliefs bequeathed by him, these exhibitions have provided the sole source of revenue, all other moneys that have come to the Academy having been either left in trust, or been constituted trusts, for certain specific purposes. The first exhibition in 1769 contained 136 works, of which more than one half were contributed by members, and brought in £699 : 17 : 6. In 1780, the first year in which the receipts exceeded the expenditure, the number of works was 489, of which nearly one-third were by members, and the sum received was £3069 : 1s. This increase continued gradually with fluctuations, and in 1836, the last year at Somerset House, the number of works was 1154, and the receipts were £5179 : 19s. No great addition to the number of works exhibited took place at Trafalgar Square, but the receipts steadily grew, and their careful management enabled the Academy, when the time came for moving, to erect its own buildings and become no longer dependent on the Government for a home. The greater space afforded by the galleries at Burlington House rendered it possible to increase the number of works exhibited, which of late years has reached a total of over 2000, while the receipts have also been such as to provide the means for further building, and for a largely increased expenditure of all kinds. It may be noted that the number of works sent for exhibition soon began to exceed the space available. In 1868, the last year at Trafalgar Square, the number sent was 3011. This has gone on increasing, with occasional fluctuations, at Burlington House, and the year 1900 saw the maximum, so far, of 13,462. The annual winter exhibition of works by old masters and deceased British artists was begun in 1870. It was never intended to be a source of revenue, but appreciation by the public has so far prevented it from being a cause of loss. The summer exhibition of works by living artists opens on the first Monday in May, and closes on the first Monday in August. The winter exhibition of works by deceased artists opens on the first Monday in January, and closes on the second Saturday in March. The galleries containing the diploma works, the Gibson statuary, and other works of art are open daily, free.

Presidents of the Royal Academy.—Sir Joshua Reynolds, 1768-92; Benjamin West (resigned) 1792-1805; James Wyatt (president-elect), 1805; Benjamin West (re-elected), 1806-20;

Sir Thomas Lawrence, 1820-30; Sir Martin Archer Shee, 1830-50; Sir Charles Lock Eastlake, 1850-65; Sir Francis Grant, 1866-78; Frederick, Lord Leighton of Stretton, 1878-96; Sir John Everett Millais, Bart., 1896; Sir Edward John Poynter, 1896.

The total number of academicians elected since the foundation, exclusive of the 36 original members, is 192, of whom 114 received their art education in the Academy schools. The total number of associates elected since the foundation, who have not reached the higher grade, inclusive of the 30 now living, is 103, of whom 46 received their art education in the Academy schools.

The total number of students admitted since 1769 is 4697, making a yearly average of about 36. The number at present on the books is 172.

The library contains about 7000 volumes, dealing with the history, the theory, and the practice of the various branches of the fine arts, some of them of great rarity and value. It is open daily to the students and members, and to other persons on a proper introduction.

The trust funds administered by the Royal Academy are:—

The *Turner fund* (J. M. W. Turner, R.A.), which provides sixteen annuities of £50 each, for artists of repute not members of the Academy, also a biennial scholarship of £50 and a gold medal for a landscape painting.

The *Chantrey fund* (Sir Francis Chantrey, R.A.), the income of which, paid over by the Chantrey trustees, is spent on pictures and sculpture.

The *Creswick fund* (Thomas Creswick, R.A.), which provides an annual prize of £30 for a landscape painting in oil.

The *Cooke fund* (E. W. Cooke, R.A.), which provides two annuities of £35 each, for painters not members of the Academy, over sixty years of age and in need.

The *Landseer fund* (Charles Landseer, R.A.), which provides four scholarships of £40 each, two in painting and two in sculpture, tenable for two years, open to students at the end of the first two years of studentship, and given for the best work done during the second year.

The *Armitage fund* (E. Armitage, R.A.), which provides two annual prizes of £30 and £10, for a design in monochrome for a figure picture.

The *Cousins fund* (S. Cousins, R.A.), which provides seven annuities of £80 each for deserving artists, not members of the Academy, in need of assistance.

The *Newton bequest* (H. C. Newton), which provides an annual sum of £60 for the indigent widow of a painter.

The *Bizo fund* (John Bizo), to be used in the scientific investigation into the nature of pigments and varnishes, &c.

The *Edwards fund* (W. J. Edwards), producing £40 a year for the benefit of poor artists or artistic engravers.

The *Leighton bequest* (Lord Leighton, P.R.A.), received from Mrs Orr and Mrs Matthews in memory of their brother, the income from which, about £300, is to be expended on the decoration of public places and buildings.

The literature concerning the Royal Academy consists chiefly of pamphlets and articles of more or less ephemeral value. More serious works are: WILLIAM SANDBY. *The History of the Royal Academy of Arts.* London, 1862 (withdrawn from circulation on a question of copyright).—*Report from the Select Committee on Arts and their Connexion with Manufactures, with the Minutes of Evidence and Appendix.* London, 1836.—*Report of the Royal Commission on the Royal Academy, with Minutes of Evidence and Appendix.* London, 1863.—MARTIN ARCHER SHEE. *The Life of Sir M. A. Shee, P.R.A.* London, 1860.—C. R. LESLIE, R.A. and TOM TAYLOR. *Life and Times of Sir Joshua Reynolds, P.R.A.* London, 1865.—J. E. HODGSON, R.A. (the late), and FRED. A. EATON, Sec. R.A. "The Royal Academy in the Last Century." *Art Journal*, 1889-91. But the chief sources of information on the subject are the minute-books of the council, and of the general assembly, and the annual reports, which, however, only date from 1859.

(F. A. E.)

Accident. See INSURANCE.

Account, a term used chiefly on the Stock Exchange to designate either the periodical settlement itself or the interval between one periodical settlement and the next. In most securities the transactions which have been effected are settled twice a month. For transactions in consols and a few kindred securities, such as India stocks, the regular settlement occurs only once a month, but a considerable part of the business in them is done "for cash," *i.e.*, for settlement immediately. For most securities except mining shares the settlement extends over three days, the account or settlement in mining shares occupying four days. The first of these days is called the "carrying-over" or "making-up" day, and is employed in adjusting the accounts open between the class of speculators known as "bulls," who buy securities for which they do not wish to pay in the hope of selling them before the settlement at higher prices, and that known as "bears," who sell securities which they do not possess in the hope of buying them before the settlement at lower prices. The second day, where there are three, and the second and third days, where there are four, are the "ticket days" or "name days," when purchasers of registered securities pass to the sellers tickets setting forth the names into which the same are to be transferred. The last is the "pay day," "settling day," or "account day," when money balances, or "differences," have to be met, and brokers who have purchased securities must be prepared to pay for them on delivery. Much of the work of the Stock Exchange account is carried out by a department of that institution corresponding to the bankers' clearing house. Its function is to bring into direct communication the ultimate buyer and the ultimate seller as represented by their respective brokers, thus eliminating, for the purposes of the settlement, the middleman known as the "dealer" or "jobber." The further returns of the bankers' clearing house, concerning which, in illustration of the financial importance of the account, figures were given in the ninth edition of the *Encyclopædia Britannica* (i. 91) down to 1873, are as follows:—

	On Fourths of the Month.	On Stock Exchange Account Days.	On Consols Settling Days.
1873	£272,156,000	£1,038,257,000	£249,755,000
1874	265,427,000	1,010,456,000	260,244,000
1875	215,810,000	1,043,464,000	251,572,000
1876	225,936,000	761,091,000	225,948,000
1877	212,640,000	744,085,000	228,254,000
1878	217,753,000	795,443,000	227,241,000
1879	213,348,000	842,937,000	225,381,000
1880	216,809,000	1,151,867,000	255,224,000
1881	253,133,000	1,383,430,000	278,864,000
1882	248,150,000	1,228,916,000	278,387,000
1883	239,080,000	1,058,703,000	254,620,000
1884	242,659,000	960,623,000	268,352,000
1885	221,873,000	935,084,000	249,327,000
1886	215,519,000	1,198,557,000	263,497,000
1887	256,469,000	1,145,842,000	297,199,000
1888	272,091,000	1,252,466,000	332,470,000
1889	290,117,000	1,338,842,000	351,690,000
1890	289,107,000	1,416,543,000	358,598,000
1891	261,501,000	1,067,403,000	314,807,000
1892	260,422,000	1,022,764,000	299,405,000
1893	268,084,000	1,002,664,000	300,478,000
1894	261,547,000	964,455,000	301,448,000
1895	283,610,000	1,304,679,000	345,446,000
1896	290,681,000	1,162,866,000	380,354,000
1897	302,123,000	1,113,682,000	362,610,000
1898	331,267,000	1,231,847,000	402,861,000
1899	359,088,000	1,544,295,000	403,042,000
1900	372,464,000	1,339,571,000	438,125,000

(S. D. H.)

Accountants.—The term "accountant" is one to which, of late years, its original meaning has been more generally attributed—that of an expert in the science of book-keeping. It is sometimes adopted by book-keepers, but this is an erroneous application of the term; it properly describes those competent to design and control the systems of accounts required for the record of the multifarious and rapid transactions of trade and finance. It assumes the possession of a wide knowledge of the principles upon which accountancy is based, which may be shortly described as constituting a science by means of which all mercantile and financial transactions, whether in money or in money's worth, including operations completed and engagements undertaken to be fulfilled at once or in a future, however remote, may be recorded; and this science comprises a knowledge of the methods of preparing statistics, whether relating to finance or to any transactions or circumstances which can be stated by numeration, and of ascertaining or estimating on correct bases the cost of any operation whether in money, in commodities, in time, in life, or in any wasting property. Generally, accountancy may be described as being the science by means of which all operations, as far as they are capable of being shown in figures, are accurately recorded and their results ascertained and stated.

History.

The origin of the profession of accountancy in Great Britain is difficult to trace; auditors of accounts were naturally of very early existence, being mentioned as officers of importance in the statutes of Westminster in the reign of Edward I. The art of accountancy on a scientific principle must certainly have been understood in Italy before 1495, when Friar Lucas de Borga published at Venice his treatise on book-keeping; but the first known English book on the science was published in London by John Gouge or Gough in 1543. It is described as *A Profitable Treatyce called the Instrument or Boke to learn to knowe the good order of the kepyng of the famouse reconynge, called in Latin, Dare and Habere, and, in Englyshe, Debitor and Creditor.* A short book of instruction was also published in 1588 by John Mellis of Southwark, in which he says, "I am but the renuer and reviver of an auncient old copie printed here in London the 14 of August 1543: collected, published, made, and set forth by one Hugh Oldcastle, Scholemaster, who, as appeareth by his treatise, then taught Arithmetike, and this booke in Saint Ollaves parish in Marke Lane." John Mellis refers to the fact that the principle of accounts he explains (which is a simple system of double entry) is "after the forme of Venice." The very interesting and able book described as *The Merchants Mirrour, or directions for the perfect ordering and keeping of his accounts; framed by way of Debitor and Creditor, after the (so tearmed) Italian manner*, by Richard Dafforne, accountant, published in 1635, contains many references to early books on the science of accountancy. In a chapter in this book, headed "Opinion of Book-keeping's Antiquity," the author states, on the authority of another writer, that the form of book-keeping referred to had then been in use in Italy about two hundred years, "but that the same, or one in many parts very like this, was used in the time of Julius Cæsar, and in Rome long before." He gives quotations of Latin book-keeping terms in use in ancient times, and refers to "ex Oratione Ciceronis pro Roscio Comædo"; and he adds: "That the one side of their booke was used for Debitor, the other for Creditor, is manifest in a certaine place, Naturalis Historiæ Plinii, lib. 2, cap. 7, where hee, speaking of Fortune, saith thus:

> Huic Omnia Expensa,
> Huic Omnia Feruntur accepta et in tota Ratione mortalium sola Utramque Paginam facit."

An early Dutch writer appears to have suggested that double entry book-keeping was even in existence among the Greeks, pointing to scientific accountancy having been invented in remote times.

There were several editions of Richard Dafforne's book printed—the second edition having been published in 1636, the third in 1656, and another was issued in 1684. The book is a very complete treatise on scientific accountancy, it was beautifully prepared and contains elaborate explanations; the numerous editions tend to prove that the science was highly appreciated in the 17th century. From this time there has been a continuous supply of literature on the subject, many of the authors styling themselves accountants and teachers of the art, and thus proving that the professional accountant was then known and employed. Very early in the 18th century the services of an accountant practising in the City of London were made use of in the course of an investigation into the transactions of a director of the South Sea Company, who had been dealing in the Company's stock. During this investigation the accountant appears to have examined the books of at least two firms of merchants. His report is described *Observations made upon examining the books of Sawbridge and Company*, by Charles Snell, Writing Master and Accountant in Foster Lane, London.

In 1799, when Holden's *Triennial Directory of London, Westminster, and Southwark* was first published, 11 individuals and firms were therein described as accountants; in the same Directory, for the period 1809-11, the number had risen to 24; and in that for 1822-24, there were 73 firms of practising accountants recorded.

Modern development.

It will be noticed that the English books dealing with scientific book-keeping, to which reference has been made, were written at a time when the English and Dutch were very actively engaged in foreign trade, in succession to the Italian merchants of the 14th, 15th and 16th centuries; but it was not until the beginning of the 19th century that, in consequence of the adoption of improved methods of manufacture and transit, resulting from the application of water and steam power to manufactures and methods of conveyance which largely increased the trade of Great Britain, the profession of an accountant became one which men of scientific knowledge and capacity adopted for their business career. Corporations and companies were formed to carry out large operations previously either left to the State or not undertaken, and for the development of trades and manufactures which were becoming less profitable when carried on by hand labour and with limited capital; and, for these, the services of public accountants were necessarily required to devise systems of accounts and methods of control, and to enable the results of the various transactions carried on to be ascertained with the least waste of power or chance of loss by negligence or fraud. The large number of companies formed in 1843 and 1844, when a great amount of capital was invested in railways and extensive speculation resulted, also added to the demand for the services of professional accountants. The Companies' Clauses Consolidation Act made provision for the audit of the accounts of companies regulated by Act of Parliament and gave some extensive powers to the auditors, who are now, to a very large extent, selected from among professional accountants. The Companies Act of 1862 led to a large extension of the business of accountants, both as auditors and liquidators of companies; and the Acts relating to bankruptcy passed between the years 1831 and 1883 added to the work devolving on professional accountants. The Companies Act 1879, which affected banking companies, made provision for the audit of their accounts, and it has been found desirable, in most cases, to appoint professional accountants to this duty. The experience and professional knowledge of trained accountants have, in fact, been utilized by their appointment as auditors in the majority of joint-stock companies, whether manufacturing, banking, trading, or created for any other purpose. Until the Companies Act 1900 was passed there was no general obligation upon limited companies to have auditors; this Act not only requires that auditors shall be appointed in all cases, but provides for their remuneration, and to a limited extent defines their rights and duties. This modification of the law relating to companies will doubtless have a beneficial effect upon their management, as it provides a very necessary control upon the operations of directors, and enables the shareholders to obtain an independent opinion on the transactions and position of the companies in which they are interested. The Legislature evidently did not find it easy to formulate at all clearly the duties of auditors, and it seems reasonable to suppose that any general definition will prove an impossibility, as the work which auditors undertake must vary very widely, and depends largely upon the scope of the operations the accounts of which are to be examined; at the same time, the provisions made mark a distinct advance in company law, and will probably create a considerable increase in the demand for the services of accountants.

Duties.

Auditors.

The duties of practising accountants cover a very wide area: they act as trustees, liquidators, receivers, and managers of businesses, the owners of which are in default or their affairs in liquidation, both under the direction of the courts and by appointment of creditors and others; they are largely engaged as arbitrators, umpires, and referees in differences relating to matters of account or finance; they prepare the accounts of executors and trustees, and the necessary statements of affairs in cases of bankruptcy, both of firms and companies; they prepare accounts for prosecutions in cases of fraud and misconduct; and they are constantly called upon to unravel and properly state the accounts of complicated transactions. Their services are commonly required to certify the profits of businesses intended to be sold, either privately or to companies by means of a published prospectus; and, in cases of compulsory purchases of businesses by railway companies and public bodies, the statements of the profits of the businesses to be acquired are generally made by them. In a very large number of financial operations they are called upon to give advice and prepare accounts, and in few business matters requiring arithmetical calculations or involving the investigation of figures, and particularly where a considerable acquaintanceship with the principles of law is needed, are their services not utilized. One of the most important duties undertaken by accountants is the audit of accounts, and this duty has, of late years, been widely extended. Originally, auditors were appointed to examine and vouch statements of receipts and payments; but the provisions made in Acts of Parliament in relation to audit, and the requirements of most articles of association of limited companies put much graver responsibilities on auditors, who are now generally required to certify to the accuracy of balance sheets and of revenue and other accounts, the performance of which duties involves far more knowledge of accounts than was once required. The efficiency, in most cases, of audits conducted by skilled accountants has led the public to attach exceptional value to their audit certificates, and to demand extensive knowledge and ability in the conduct of the audit of the accounts of public companies. One other requirement which is generally regarded as indispensable, is that the work of audit should be very expeditiously performed; for it is easy to understand that, were the presentation of the accounts of a company and the distribution of dividends materially delayed in consequence of the audit, much inconvenience would result, while the value of the criticism of the accounts of business operations would be much deteriorated if it could not be made very shortly after the accounts were closed. In these circumstances, in the cases of large concerns with wide ramifications and numerous transactions, it is necessary that auditors should have the help of trained assistants, and thus the personal examination of details by the auditor himself is, to a large extent, rendered unnecessary and the cost of audit materially reduced. This delegation of duty by auditors is generally well understood, and is in accordance with the requirements of those concerned; but there has been a tendency of late years to enlarge the responsibilities of auditors to an extent which, if persisted in, might render it dangerous for men of reputation and means to accept the duties. It is to be hoped that future legislation may, on the one hand, secure the faithful performance of difficult work by competent men; and, on the other, not leave an auditor responsible to the extent of his means either for some carelessness on the part of a clerk, or for an inaccurate decision at a time of pressure on a matter respecting which he is probably unable to obtain competent advice without disclosing that which it is his duty to keep secret.

Organization.

While the number of practising accountants has of late years been steadily increasing and their services are correspondingly appreciated, the necessity for controlling those exercising the profession and for improving its status has naturally become apparent. The first important steps in this direction were taken by the accountants in Scotland—the Society of Accountants in Edinburgh being incorporated by royal charter in 1854; similar societies in Glasgow and Aberdeen being also incorporated by charter in 1855 and 1867. The Institute of Accountants was formed in London in 1870, but did not receive a royal charter until the 11th May 1880, when all the then existing accountants' societies and institutes in England were incorporated as the Institute of Chartered Accountants in England and Wales, and means were provided by which all the then practising accountants in these countries could claim membership thereof. In the year 1885 the Society of Accountants and Auditors was incorporated, but has obtained no charter; this body, while numbering among its members a considerable number of practising accountants in the United Kingdom, also includes treasurers and accountants to cities and boroughs in England, as well as clerks to chartered and other accountants. A large proportion of its members also consists of accountants practising abroad. In 1888 an Institute of Chartered Accountants was formed in Ireland, and a great many institutes and societies have been formed in the British colonies and in the United States, some of which have local charters. It is curious to note, however, that, outside the United Kingdom, it was only in the British colonies, and lately in America, that associations of practising accountants existed, until, in 1895, an Institute of Accountants was founded in Utrecht for Dutch accountants; when, although the principles of accountancy have been well understood and practised in Holland since the 16th century, and probably earlier, it was found necessary to borrow the words "accountant" and "accountancy" from the English language to convey to the Dutch an idea of the meaning of the terms.

The Institute of Chartered Accountants in England and Wales, on the 1st June 1900, numbered 3195 members, of whom 2469 were practising in England and Wales, and 119 were practising abroad; the majority of the other members (607) having passed the qualifying examinations of the Institute. In the three chartered bodies in Scotland there were, at the end of 1899, 698 members, of whom about four-fifths were in practice; and the Irish Institute numbered 50 members, of whom 42 were in practice. The list of 1344 members of the Society of Accountants and Auditors in the United Kingdom, dated June 1900, does not enable a classification to be made between those practising as accountants and those otherwise engaged; but it may fairly be assumed that about five-eighths of this number were practising. Making an allowance for public accountants who are not members of any of the institutes and societies mentioned above, it would appear that about 4000 persons were, at the beginning of the year 1900, practising as public accountants in the United Kingdom. (J. G. G*L.)

Accra. See GOLD COAST.

Accrington, a municipal borough (1878), in the Accrington parliamentary division of Lancashire, England, 19 miles N. of Manchester by rail. Modern erections are Established, Free, Congregational, Baptist, and Methodist churches, and a municipal technical school. Dye-works, chemical manufactures, and manufactures of machinery for the cotton-mills have been established. Area, 3425 acres. Population in 1881, 31,435; in 1891, 38,603; in 1901, 43,076.

ACCUMULATORS.

THE early study of electrolysis made scientific men acquainted with what were called secondary currents and polarization. The former were first used by Grove, whose gas battery may be called the first accumulator; but systematic search for the best effects was not undertaken till 1859, when Planté began a masterly and fruitful investigation. He soon produced his well-known battery, a cell with higher electromotive force and greater current-yielding power than any other practical combination. He obtained these results by putting lead plates into dilute sulphuric acid and sending a current through; after a few reversals he found one plate to be covered by peroxide of lead, the other with a porous mass of lead. He set himself to *accumulate* energy in the cell, by which he meant the formation of a quantity of the active materials. The names given to Planté's first cell have been frequently misunderstood. The terms secondary battery, storage battery, and accumulator have been taken to indicate that there was an accumulation or storage of electricity or of electric current; but the error is not Planté's, as is clear from his declaration that his couple is able to give discharges of long duration, or to retain its charge for a long time, "et d'emmagasiner ainsi le *travail chimique* de la pile voltaïque." The value of the cell arises from a happy combination of properties. The three active materials are peroxide of lead, spongy metallic lead, and dilute sulphuric acid. Of these, the peroxide is an excellent depolarizer; the lead is a sufficiently good electropositive metal; and the dilute sulphuric acid has a very high conductivity for an electrolyte. Moreover, the two solid substances are not only themselves insoluble in the dilute acid, but the sulphate of lead formed from them in the course of discharge is also insoluble. Consequently, it remains fixed in the place where it is formed; and on the passage of the charging current, the original PbO_2 and Pb are reproduced in the places they originally occupied. Thus there is no material change in the distribution of masses of active material. Lastly, the active materials are in a porous, spongy condition, so that the acid is within reach of all parts of them. The resistance of the cell is low, while the energy of the chemical action to which it gives rise imparts a high electromotive force.

Planté's cell.

Planté carefully studied the changes which occur in the formation, charge, and discharge of the cell. In forming, he placed two sheets of lead in sulphuric acid, separating them by narrow strips of caoutchouc (Fig. 1). When a charging current is sent through the cell, the hydrogen liberated at plate A escapes, a small quantity possibly being spent in reducing the surface film of oxide generally found on lead. Some of the oxygen is always fixed on the positive plate B, forming a surface film of peroxide. After a few minutes the current is reversed, plate A is peroxidized, while the peroxide previously formed on B is reduced to metallic lead in a spongy state. By repeated reversals, the surface of each plate is alternately peroxidized and reduced to metallic lead. In successive oxidations, the action penetrates farther into the plate, furnishing each time a larger quantity of spongy PbO_2 on one plate and of spongy lead on the other. It follows that the duration of the successive charging currents also increases. At the beginning, a few minutes suffices; at the end, many hours are required. After the first six or eight cycles, Planté allowed a period of repose before reversing. He claimed that the PbO_2 formed by reversal after repose was more strongly adherent, and also more crystalline than if no repose were allowed. The following figures show the relative amounts of oxygen absorbed by a given plate in successive charges (between one charge and the next the plate stood in repose for the time stated, then was reduced, and again charged as anode):—

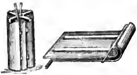


Fig. 1.

Separate Periods of Repose.	Charge.	Relative Amount of Peroxide formed.
...	First	1·0
18 hours	Second	1·57
2 days	Third	1·71
4 "	Fourth	2·14
2 "	Fifth	2·43

and so on for many days.—(Gladstone and Tribe, *Chemistry of Secondary Batteries*). Seeing that each plate is in turn oxidized and then reduced, it is evident that the spongy lead will increase at the same rate on the other plate of the cell. The process of "forming" thus briefly described was not continued indefinitely, but only till a fair proportion of the thickness of the plates was converted into the spongy material, PbO_2 and Pb respectively. After this, reversal was not permitted, the cell being put into use and always charged in a given direction. If the process of forming by reversal be continued, the positive plate is ultimately all converted into PbO_2 and falls to pieces.

Planté made excellent cells by this method, yet three objections were urged against them. They required too much time to "form"; the spongy masses (PbO_2 more especially) fell off for want of mechanical support, and the separating strips of caoutchouc were not likely to have a long life. The first advance was made by Faure (1881), who greatly shortened the time required for "forming" by giving the plates a preliminary coating of red lead, whereby the slow process of biting into the metal was avoided. At the first charging, the red lead on the + electrode is changed to PbO_2, while that on the − electrode is reduced to spongy lead. Thus one continuous operation, lasting perhaps sixty hours, takes the place of many reversals, which, with periods of repose, last as much as three months. Faure used felt as a separating membrane, but its use was soon abolished by methods of construction due to Volckmar, Sellon, Swan, and others. These inventors put the paste not on to plates of lead, but into the holes of a grid, which, when carefully designed, affords good mechanical support to the spongy masses and does away with the necessity for felt, &c. They are more satisfactory, however, as supporters of spongy lead than of the peroxide, since at the point of contact in the latter case the acid gives rise to a local action, which slowly destroys the grid. Disintegration follows sooner or later, though the best makers are able to defer the failure for a fairly long time. Efforts have been made by Tribe, Fitzgerald, and others to dispense with a supporting grid for the positive plate, but these attempts have not yet been successful enough to enable them to compete with the other forms.

The following description of well-known forms of cells will illustrate the methods adopted at the present time.

Chloride accumulators.

Planté Type.—"Chloride Accumulator" cells derive their name from the fact that chloride of lead is used in making the negative plates. There is no chlorine or chloride in the cell when ready for use. For the negative plates, the chloride of lead is melted in large iron pans at a temperature of about 600° C., and then carried by plumbago crucibles to a mould, where it is cast into short hexagonal prisms or pastilles. These are arranged in the bottom half of a plate mould, the top half of which is permanently fixed to a hydraulic press; the press is closed and molten lead is injected under a pressure of 150 lb per square inch, to fill in the spaces between them. They are thus embedded in a lead plate whose thickness is equal to their own length, their ends being flush with the face of the plate. The chlorine has now to be extracted, which is done by putting the plate between sheets of zinc in chloride of zinc solution, when the zinc takes chlorine from the lead chloride, and leaves the metallic lead in a finely-divided, porous condition in the space previously occupied by the chloride. After several washings, the plate is made a negative pole in sulphuric acid for a little while, to ensure absolute freedom from chlorine, and is then ready for use. Fig. 2 shows the negative plate in position in a cell. The holes in the hexagonal plugs are to facilitate diffusion of acid. For the positive plates, lead grids are first cast under pressure, the mould being arranged to give a plate of lead 0·4 inch thick, pierced by a number of circular holes about half an inch in diameter with slight countersinks on the faces. Into each of these holes is thrust a roll or rosette of lead ribbon, which has first been cut to the right breadth (equal to the thickness of plate), then ribbed or gimped, and finally coiled into a rosette. The rosettes have sufficient spring to fix themselves in the circular holes of the lead plate, but are keyed into position by putting the plate through a hydraulic press. The plates are then put into tanks with temporary negatives, and a current is passed for a long time, whereby the rosettes become coated with a fine adherent hard crystalline peroxide. The cell can be discharged at very high rates; one square foot of plate will give a current of 40 amperes when necessary.

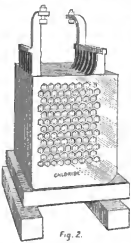


Fig. 2.

"D.P." cell.

A second cell of the Planté type is that known as the "D.P." Its construction is very simple (Fig. 3). A number of corrugated lead strips, about one quarter of an inch wide, are piled to a height of 7 or 8 inches, and their ends are burned together. Thus a plate is formed through which the acid can easily pass. A number of such plates are joined together to form the positives, the negatives being formed by pasting a somewhat similar framework with litharge. Having put the two sets of plates into the cells, a prolonged charging current is sent through; the litharge is reduced to spongy lead, and the surface of the corrugated strips which form the positive plate becomes covered with peroxide.

"Monobloc" cell.

In the "Monobloc" cell, the general appearance and arrangement of which are shown in Fig. 4, the positive block is built up of corrugated sheets of lead, perforated by rectangular holes. When these perforated sheets have been laid on each other to a height of about 9 inches, and the four corners burned to stout lead fillets, a very compact block is obtained, to all parts of which acid is able easily to penetrate. The negative plate consists of a series of rods, each having a lead core on which lies spongy lead. These are burned to a lug at the top, and each rod being enclosed in a perforated ebonite sheath the whole is put into the perforations of the positive blocks. These cells have been used on the tramway cars at Ghent and other places on the Continent.

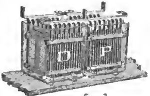


Fig 3

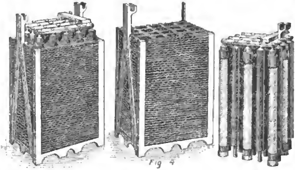


Fig 4

E.P.S. cell.

Pasted Types.—The best-known cell of this type is the E.P.S. cell, made by the Electric Power Storage Company. The paste for the positive plates is a mixture of red lead with sulphuric acid, and for the negative plates litharge is used instead of red lead. Different forms of grids are adopted, according to the special purpose for which the cells are intended. For ordinary isolated installations, the grid wall has a section shown in Fig. 5, the holes *h*, as seen from the direction of the arrow, being square and slightly larger on the negative than on the positive grid. For rapid discharges (up to two hours) the negative grid is much the same, except that the holes

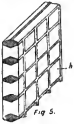


Fig 5.

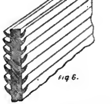


Fig 6.

are rectangular and the plate is thicker. The positive grid has quite a different shape (Fig. 6). For the quickest discharges (up to one hour or less) the grid has the form of thin vertical ribs $\frac{1}{10}$th inch apart, strengthened at intervals by horizontal ribs. Between the vertical ribs are deep narrow grooves, which hold the active material. The negative grid is like Fig. 5, the holes being rectangular in shape.

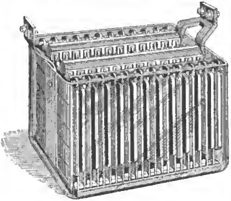


Fig 7

Fig. 7 shows the general appearance of the two-hour discharge cell, illustrating the method of connecting, and the greater thickness of the positive over the negative plate; also, the clearance between the plates and the bottom of the cell. There are other types of grids besides those mentioned, to suit the varying conditions of electrical work, for high discharge, traction, &c.

Hart cell.

Another cell of pasted type is that known as the "Hart" accumulator. The positive and negative plates, which are similar in size and shape, are pasted with red lead and litharge respectively. The grid is in the form of lattice work, arranged alternately on either side, with strong leaden ribs running diagonally across the plate. The active material in each plate is split up into a number of small pellets, each of which is gripped hard on its surface by means of a leaden lip attached to the grid and turned over by a special process. In joining up, a special terminal is used. The lugs are first faced up against each other and tightened by a temporary master connector. This then gives way to a non-corrosive bolt, which is conically tapered and gives a large connecting surface. Fig. 8 gives a view of the cells and also of the connector.

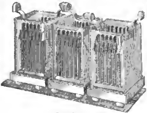


Fig 8

"Tudor" cell.

Mixed Type.—In this type, of which the "Tudor" cell is a well-known example, the positives are prepared by a pure Planté formation from a carefully-made lead casting, and the negatives by pasting. Fig. 9 shows the unformed positive plate. A mould is made by supporting narrow gun-metal racks on each side of a cast-iron frame. The teeth of the racks form vertical grooves in the faces of the casting; and as narrow spaces are left between one rack and the next lower or higher one, horizontal ribs are seen. To give greater strength, thicker vertical ribs are obtained by cutting out one tooth of each rack at intervals. The grooves are about $\frac{1}{12}$th inch apart and $\frac{1}{4}$ inch deep. The positive plates are about $\frac{1}{2}$ inch thick, and are formed (that is, covered with peroxide) by charging them, and leaving them on open circuit (repose) alternately. Later, charging and discharging are substituted. Here, as in Planté's work, charging and discharging become more prolonged as the formation proceeds. As much as five or six weeks is required. The negative plate is a pasted plate. Litharge mixed with sulphuric acid is placed in the holes of a lead grid, to which, before pasting, is given a superficial coating of peroxide by making it a terminal in an acid bath and charging it as a positive for a short time. This gives a greater attachment between the grid and the spongy lead when subsequently reduced. The negative plate is about $\frac{4}{16}$th inch thick.

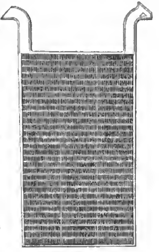


Fig 9.

There are many other types of cells. An interesting one is that known as the Lithanode. Originally, this was an attempt to prevent local action by making the positive of peroxide alone, and to form it so slowly that its mechanical arrangement and strength would facilitate diffusion and prevent disintegration. It has not yet been largely used.

Erecting cells.

Whatever the type of cell may be, it is important to attend to the following working requirements:—(1) The cells must be fully equal to the maximum demand, both in discharge rate and capacity. (2) All the cells in one series ought to be equal in discharge rate and capacity. This involves similarity of treatment. (3) The cells are erected on strong wooden stands. Where floor space is too expensive, they can be erected in tiers; but if possible this should be avoided. They ought to lie in rows, so arranged that it is easy to get to one side (at least) of every cell, for examination and testing, and if need be to detach and remove it or its plates. Where a second tier is placed over the first, sufficient clearance space must be allowed for the plates to be lifted out of the lower boxes. The cells are insulated by supporting them on glass or mushroom-shaped oil insulators. If the containing vessels are made of glass, it is desirable to put them in wooden trays which distribute the weight between the vessel and insulators. To prevent acid spray from filling the air of the room, a glass plate is arranged over each cell. The positive and negative sections are fixed in position with insulating forks or tubes, and the positive terminal of one cell is joined to the negative of the next by burning or bolting. If the latter method is adopted, the surfaces ought to be very clean and well pressed home. The joint ought to be covered by vaseline or varnish. When this has been done, examination ought to be made of each cell to see that the plates are evenly spaced, that the separators (glass tubes or ebonite forks between the plates) are in position and vertical, and that there are no scales or other adventitious matter connecting the plates. The floor of the cell ought to be quite clear; if anything lies there it must be removed. (4) To mix the solution a *gentle stream* of sulphuric acid must be poured into the water (not the other way, lest too great heating cause an accident). It is necessary to stir the whole as the mixing proceeds and to arrange that the density is about 1190, or according to the recommendation of the maker. About five volumes of water ought to be taken to one volume of acid. After mixing, allow to cool for two or three hours. The strong acid ought to be free from arsenic, copper, and other similar impurities. The water ought to be as pure as can be obtained, distilled water being best; rain water is also good. If potable water be employed, it will generally be improved by boiling, which removes some of the lime held in solution. The impurity in ordinary drinking water is very slight; but as all cells lose by evaporation and require additions of water from time to time, there is a tendency for it to increase. The acid must not be put into the cells till everything is ready for charging. (5) A shunt-wound or separately-excited dynamo being ready and running so as to give at will 2·6 or 2·7 volts per cell, the acid is run into the cells. As soon as this is done, the dynamo must be switched on and charging commenced. The positive terminal of the dynamo must be joined to the positive terminal of the battery. If necessary, the + end of the machine must be found by a trial cell made of two plain lead sheets in dilute acid. It is important also to maintain this first charging operation for a long time without a break. Twelve hours is a minimum time, twenty-four not too much. The charging is not even then complete, though a short interval is not so injurious as in the earlier stage. The full charge required varies with the cells, but in all types a full and practically continuous first charge is imperatively necessary. During the early part of this charge the density of the acid may fall; but after a time ought to increase, and finally reach the value desired for permanent working. Towards the end of the "formation" vigilant observation must be exercised. It is important to notice whether any cells are appreciably behind the others in voltage, density, or gassing. Such cells may be faulty, and in any case they must be charged and tended till their condition is like that of the others. They ought not to go on the discharge circuit till this is assured. The examination of the cells before passing them as ready for discharge includes:—(*a*) Density of acid as shown by the hydrometer. (*b*) Voltage. This may be taken when charging or when idle. In the first case it ought to be from 2·4 to 2·6 volts, according to conditions. In the second case it ought to be just over 2 volts, provided that the observation is not taken too soon after switching off the charging current. For about half an hour after that is done, the E.M.F. has a transient high value, so that, if it be desired to get the proper E.M.F. of the cell, the observation must be taken thirty minutes after the charging ceases. (*c*) Eye observations of the plates and the acid between them. The positive plates ought to show a rich dark brown colour, the negatives a dull slate blue, and the space between ought to be quite clear and free from anything like solid matter. All the positives ought to be alike, and similarly all the negatives. If the cells show similarity in these respects, they will probably be in good working order.

As to management, it is important to keep to certain simple rules, of which these are the chief:—(1) Never discharge below a potential difference of 1·85 (or in rapid discharge, 1·8) volt. (2) Never leave the cells discharged, if it be avoidable. (3) Give the cells a special full charging once a month. (4) Make a periodic examination of each cell, determining its E.M.F., density of acid, the condition of its plates, and freedom from growth. Any incipient growth, however small, must be carefully watched. (5) If any cell shows signs of weakness, keep it off discharge till it has been brought back to full condition. See that it is free from any connexion between the plates which would cause shortcircuiting; the frame or support which carries the plates sometimes gets covered by a conducting layer. To restore the cell, two methods can be adopted. In private installations it may be disconnected and charged by one or two cells reserved for the purpose; or, as is preferable, it may be left in circuit, and a cell in good order put in parallel with it. This acts as a "milking" cell, not only preventing the faulty one from discharging, but keeping it supplied with a charging current till its P.D. is normal. Every battery attendant should be provided with a hygrometer and a voltmeter. The former enables him to determine from time to time the density of the acid in the cells; instruments specially constructed for the purpose are now easily procurable, and it is desirable that one be provided for every 20 or 25 cells. The voltmeter should read up to about 3 volts and be fitted with a suitable connector to enable contacts to be made quickly with any desired cell. A portable glow lamp should also be available, so that a full light can be thrown into any cell; a frosted bulb is rather better than a clear one for this purpose. He must also have some form of wooden scraper to remove any growth from the plates. The scraping must be done gently, with as little other disturbance as possible. By the ordinary operations which go on in the cell, small portions of the plates become detached. It is important that these should fall below the plates, lest they shortcircuit the cell, and therefore sufficient space ought to be left between the bottom of the plates and the floor of the cell for these "scalings" to accumulate without touching the plates. It is desirable that they be disturbed as little as possible till their increase seriously encroaches on the free space. It sometimes happens that brass nuts or bolts, &c., are dropped into a cell; these should be removed at once, as their partial solution would greatly endanger the negative plates. The level of the liquid must be kept above the top of the plates. It may sometimes be necessary to replenish the solution with some dilute acid, but strong acid must never be added.

The chief faults are buckling, growth, sulphating, and disintegration. Buckling of the plates generally follows excessive discharge, caused by abnormal load or by accidental shortcircuiting. At such times asymmetry in the cell is apt to make some part of the plate take much more than its share of the current. That part then expands unduly, as explained later, and curvature is produced. The only remedy is to remove the plate, and press it back into shape as gently as possible. Growth arises generally from scales from one part falling on some other; say, on the negative. In the next charging the scale is reduced to a projecting bit of lead, which grows still further because other particles rest on it. The remedy is, gently to scrape off any incipient growth. Sulphating, the formation of a white hard surface on the active material, is due to neglect or excessive discharge. It often yields, if a small quantity of sulphate of soda be added to the liquid in the cell. Disintegration is due to local action, and there is no ultimate remedy. The end can be deferred by care in working, and by avoiding strains and excessive discharge as much as possible.

Accumulators in repose.

Accumulators contain only three active substances—spongy lead on the negative plate, spongy peroxide of lead on the positive plate, and dilute sulphuric acid between them. It will be shown later that a fourth substance, sulphate of lead, is formed on both plates during discharge, and also, though to a small extent, during repose. *Spongy lead* looks much like ordinary lead. Its colour is a blue gray, density probably similar to that of lead, 11·3, and its electric resistance ·0000195 ohm between opposite faces of a cubic centimetre. *Spongy peroxide of lead* is a dark brown crystalline powder, with a density of 9·28. Its electric conductivity has been determined by J. Shields (*Chemical News*, 65, 87). The hydrated peroxide prepared by purely chemical methods had a specific resistance of $5·59 \times 10^9$ c.g.s. units ($= 5·59$ ohms); but a similar hydrate, prepared electrolytically, gave slightly higher figures, $6·78 \times 10^9$ c.g.s., or 6·78 ohms. Both forms of this substance conduct metallically, and neither of them electrolytically. *Sulphate of lead* is a white powder, with a density of 6·3. Its electric conductivity is so low that it may be classed as a non-conductor. The densities of these three solids being known, it is easy to follow the changes in volume which accompany the formation of sulphate of lead on either plate. One hundred volumes of lead (on the negative plate) form 290 volumes of sulphate, and will therefore require three times as much space as before the action, while 100 volumes of peroxide (on the positive plate) form 186 volumes of sulphate, and will therefore fill nearly twice as much space as before. These expansion figures are not only important in themselves, but also

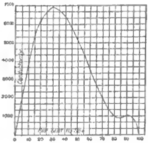


Fig 10.

throw light on the well-known tendency of the negative plate to run down before the positive. In a given discharge the quantities of sulphate of lead formed on the two lead plates are the same, but the expansion in the lead plugs (and consequent reduction of porosity) is 60 per cent. greater than in the positive plugs. *Sulphuric acid* is used in the dilute state. The usual density employed is 1·210, which has an electric conductivity of 0·73 c.g.s. units, or a specific resistance of 1·37 ohm for a centimetre cube. The relative conductivity (the reciprocal of resistance) is shown in Fig. 10. From this and the datum just given, the specific resistance of any strength of acid can be found approximately.

Local action.

There are three kinds of local action:—(1) In all the practical forms of accumulator the positive plate contains two conductors in contact—the lead grid or plate and the peroxide it is intended to support. There exists between them a difference of potential (= 2 volts), and, as the acid touches both, local currents must flow. The course of these will be from a point in the positive grid to the acid, thence to the adjacent peroxide, and back through it to the grid beneath. Such currents involve the formation of sulphate from both the grid and the peroxide, with two definite results: (*a*) a diminution of the available energy existing as peroxide, and (*b*) an attack on the lead-supporting surface below. In an early form of accumulator, Gladstone and Tribe found 7 per cent. of sulphate was formed in two hours. Fortunately the sulphate of lead thus formed is insoluble, and covers the free lead surface. Consequently the action becomes very slow after the first hour or so, and would in fact stop altogether if the film of sulphate remained intact, and so prevented access of acid to the lead surface. But in the daily changes of temperature, &c., the strains are great enough to cause some conducting communication, and the local action goes on. This progressive action explains the advantage Planté derived from periods of repose in forming, since it brings a greater quantity of the lead within the reach of the next operation. It also explains the danger which waits on the positive grid or plate, and ultimately leads to its destruction. (2) Local action will arise on the negative plate if a more electro-negative conductor settle on the lead. This sometimes happens because of impurities in the materials used for the paste or existing in the acid. In either case they will find their way to the negative grid or support, and lead to loss of energy and the evolution of hydrogen gas. (Swinburne, *Journ. Inst. Elec. Eng.* 1886.) Even where impurities do not exist in the materials, they are often introduced by small bits of metal being carelessly dropped into the cell. A not unusual habit of engineers is to scrape copper connecting-wires in close proximity to the cells, thus endangering their capacity and life very considerably. Besides this chance of local action on the negative plate, acid of density 1·210 acts directly on the finely-divided lead. Swinburne also drew attention to this in 1886, and indicated its effect on the capacity of the cells, which may be seriously reduced. (3) There is a local action on each of the plates, whenever the acid in one part of the cell differs in density from that in another. This often happens. There is a constant tendency for the acid to get stronger at the bottom of the cell, because during charge the stronger acid brought to the positive plate tends to fall, and in discharge the weaker acid diffusing from the porous plugs of both plates tends to rise. Further still, during charge the acid is strongest in the inner parts of the spongy material, and differences of 25 to 30 per cent. may exist between the inner and outer parts of a plug. A similar difference may exist during discharge, but in this case the acid is strongest on the outside and weakest in the interior. The following table gives the E.M.F. between a plate of peroxide in weak and another in strong acid; corresponding values are also given for lead plates in acid of different strength (Gladstone and Hibbert, *Journ. Inst. Elec. Eng.* 1892):—

E. M. F. arising from Differences in Strength of Acid.

Two lead plates.			Two peroxide plates.		
Acid round + lead plate.	Acid round − lead plate.	E. M. F. in volts.	Acid round − PbO_2 plate.	Acid round + PbO_2 plate.	E. M. F. in volts.
Per cent.	Per cent.		Per cent.	Per cent.	
0·2	1·35	0·047	0·2	1·35	0·072
,,	2·85	0·060	,,	2·85	0·095
,,	5·5	0·066	,,	5·5	0·107
,,	10·5	0·082	,,	10·5	0·134
,,	14·5	0·094	,,	14·5	0·150
,,	22·5	0·109	,,	22·5	0·168
,,	36·5	0·150	,,	36·5	0·215
,,	57·5	0·204	,,	57·5	0·359
,,	85·5	0·247	,,	85·5	0·537
,,	98·0	0·268	,,	99·0	0·643

The lead in the weaker acid is + to the other; with the peroxide plates the case is reversed. With these figures it is easy to picture the local currents flowing between an inner and an outer part of a single plug during the discharge, owing to the different strength of acid then existing.

The importance of these three kinds of local action arises not so much from the magnitude of the actions they set up as from the special parts of the plates affected by them. Sulphate of lead is formed in each case, but not in the course or path of the regular current. On the positive plate the local action forms sulphate along the interface between the plugs and the grid, and may effectively isolate a large proportion of the peroxide. On the negative plate, when due to deposited copper, &c., it cannot be so definitely followed, but may even give an outside surface coating of sulphate. That arising on both plates by reason of variable acid strength in the plugs cannot be localized, but must necessarily be out of the regular lines of flow of the working currents. It is partly by virtue of these special localizations of the chemical changes that an accumulator seems to be seriously damaged by a rest, whether charged or discharged, and it is a further consequence that subsequent charges only slowly get at this deep-seated sulphate, so that many cycles of work are required to bring back the cell to its earlier value as a working machine.

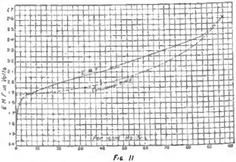


Fig. 11

Electromotive force.

The electromotive force of a cell varies with the strength of the acid, as may be seen from Fig. 11, taken from Gladstone and Hibbert's paper. The observations with very strong acid were very difficult to obtain; but one good experiment made with

98 per cent. acid is marked by x. Streintz (*Ann. Phys. Chem.* 46, p. 449) gives for the E.M.F. the expression

$$E = 1{\cdot}850 + 0{\cdot}917\,(s - s_0)$$

between the density limits 1·055 and 1·279; $(s - s_0)$ is the excess of the specific gravity of the acid over that of water. It must be understood that the acid referred to in the foregoing curve is that existing in the pores of the spongy masses of the plates. If there be any inequality between that and the acid outside a process of diffusion sets in between them, and the E.M.F. varies so rapidly that no exact measurement can be made. The importance of this diffusion was first pointed out by Duncan and Wiegand (*Electrical World*, N.Y. 1889), who took plates before and after discharge, soaked them in sulphuric acid of 1·175 density, and then transferred them to vessels of distilled water. The acid which diffused out in a given time was estimated, with the results shown in Fig. 12.

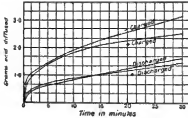


FIG. 12.

The plates contained about 5 grams of acid altogether, so that about one-half diffused out in thirty minutes, a good illustration of the slowness of diffusion. It is noteworthy that the rate of diffusion is much the same for both positive and negative plates, but that the rate for a discharged is considerably less than that for a charged plate. This last difference is undoubtedly due to the formation of sulphate in the porous plugs, with the expansions indicated in the paragraph on the properties and volumes of materials. Discharge affects the rate of diffusion on the lead plate more than on the peroxide. This is in accordance with the higher rate of expansion and clogging when lead is changed to sulphate over the change from peroxide to sulphate. From what has already been said about the dependence of E.M.F. on acid strength, it is obvious that while diffusion is proceeding there will be a corresponding change in E.M.F. Curve I., in Fig. 13, shows the rise when a positive plate, hitherto standing in 20 per cent. acid, is suddenly placed in 34 per cent.; curve II., the rise when a similar plate is taken from 20 to 58 per cent. acid (Gladstone and Hibbert, *Phil. Mag.* 1890).

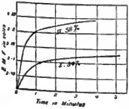


Fig 13

In applying these diffusion and electromotive force curves to working conditions, it may be noticed that a given quantity of H_2SO_4 diffusing into very weak acid produces a much greater change in the electromotive force than if it pass into stronger acid. Thus if the acid be very weak, say, 2 per cent., a diffusion of 1 per cent. H_2SO_4 raises the E.M.F. by 0·036 volt, whereas if the acid be 10 per cent. a diffusion of 1 per cent. raises the E.M.F. by 0·006 volt only (see Fig. 11).

The important practical questions concerning an accumulator are—its maximum rate of working, its capacity at various discharge rates, its efficiency, and its length of life. Apart from mechanical injury, all these depend on the way the cell is charged and discharged. For each type and size of cell there is a normal maximum current. Up to this limit any current may be taken, beyond it the cell may suffer. Again, it is desirable that the charge and discharge be confined between certain limits of potential difference at the terminals. Injuriously excessive currents or a discharge below a potential difference of 1·8 volt are often accompanied by more or less disintegration. To illustrate and explain these points a connected series of observations on a given set of cells is here used, the data having been given by Ayrton, Lamb, Smith, and Woods (*Journ. Inst. Elec. Eng.* 1890). The cells employed contained three negative plates, weighing 17 lb 2 oz., two positive plates, weighing 11 lb 8 oz., and acid of 1·206 density. The plates measured 9 by 9 inches, and were intended for maximum currents of 9 amperes in charging and 10 amperes in discharging. For reasons given in the paper, it was decided to make the potential difference at terminals the governing condition of working, the limits to be 2·4 and 1·6 volt.

Charge and discharge.

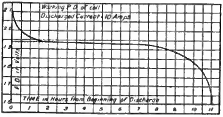


Fig 14

Fig. 14 shows a typical discharge curve; noteworthy points are:—(1) At the beginning and at the end there is a rapid fall in P.D., with an intermediate period of fairly uniform value. (2) When the P.D. reaches 1·6 volt the fall is so rapid that there is no advantage in continuing the action. When the P.D. had fallen to 1·6 volt the cell was automatically switched into a charging circuit, and with a current of 9 amperes yielded the curve in Fig. 15. Here again there is a rapid variation in P.D. (in these cases a rise) at the beginning and end of the operation. The cells were now carried through the same cycle several times, giving almost identical values for each cycle. After some days, however, they became more and more difficult to charge, and the return on discharge was proportionately less. It became impossible to charge up to a P.D. of 2·4 volts, and finally the capacity fell away to half its first value. Examination showed that the plates were badly scaled and that some of the scales had partially connected the plates. These scales were cleared away and the experiments resumed, limiting the fall of P.D. to 1·8 volt. The difficulties then disappeared,

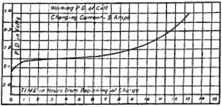


Fig 15

showing that discharge to 1·6 volt caused injury that did not arise at a limit of 1·8. Before describing the new results it will be useful to examine these two cases in the light of the theory of E.M.F. already given.

(*a*) *Fall in E.M.F. at beginning of discharge.*—At the moment when previous charging ceases the pores of the positive plate contain strong acid, brought there by the charging current. There is consequently a high E.M.F. But the strong acid begins to diffuse away at once and the E.M.F. falls rapidly. Even if the cell were not discharged this fall would occur, and if it were allowed to rest for thirty minutes or so the discharge would have begun with the dotted line (Fig. 14). (*b*) *Final rapid fall.* The pores being clogged by sulphate the plugs cannot get acid by diffusion, and when 5 per cent. is reached the fall in E.M.F. is disproportionately large (see Fig. 11). If discharge be stopped, there is an almost instantaneous diffusion inwards and a rapid rise in E.M.F. (*c*) *The rise in E.M.F. at beginning and end of the charging* is due to acid in the pores being strengthened, partly by diffusion, partly by formation of sulphuric acid from sulphate, and partly by electrolytic carrying of strong acid to the positive plate. The injurious results at 1·6 volt arise because then the pores contain water. The chemistry is altered, oxide or hydrate is formed, which will partially dissolve, to be changed to sulphate when the sulphuric acid subsequently diffuses in. But formed in this way it will not appear mixed with the active masses in the electrolytic paths, but more or less alone in the pores. In this position it will more or less block the passage and isolate some of the peroxide. Further, when forming in the narrow passage its disruptive action will tend to force off the outer layers. It is evident that limitation of P.D. to 1·8 volt ought to prevent these injuries, because it prevents exhaustion of acid in the plugs. The other curves will now be easy to follow. Figs. 16 and 17 show a normal charge and discharge between the limits of 2·4 and 1·8 volt.

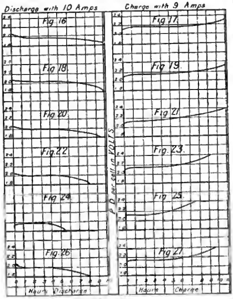


Fig. 16-27.

After the next charging the cells were allowed to rest for ten days. On discharge they showed a smaller capacity, and this was the case for several subsequent charges and discharges, though repeated chargings at last brought them back to something like the previous values. Compare Figs. 18 and 19. Two other similar series were tried; that is, rest followed by repeated and continuous work to bring the cell back to its first state (see Figs. 20, 21, 22, 23). Then another charge was followed by a rest of sixteen days. The discharge which *immediately followed* the rest is shown in Fig. 24, while Fig. 25 shows the next charge—a great falling-off. The cells were now taken through eight cycles of charge and discharge, and were then so far restored as to give Figs. 26 and 27. Integrating the curves, the following numbers were obtained:—

Experiment.	Capacity and Efficiency under Various Conditions of Working.					
	Discharge.		Charge.		Efficiency.	
	Ampere Hours.	Watt Hours.	Ampere Hours.	Watt Hours.	Quantity.	Energy.
Normal cycle .	102	201·7	104·5	230·7	97·2	87·4
Restoration after 1st rest .	100	190	103·8	228·2	96·8	85·8
Ditto, after 2nd rest . .	91	176·7	96·8	213·2	94·1	82·8
Ditto, after 3rd rest . .	82·6	161·3	86·2	190·5	95·8	84·7
Discharge immediately after rest	56·5 56·5	110·5 110·5	86·2 71·1	190·5 158·3	65·5 79·6	58[1] 69·6
Restoration after 8 cycles .	80	156·9	83·8	184·6	95·5	85

The table shows that the efficiency in a normal cycle may be as high as 87·4 per cent.; that during a rest of sixteen days the charged accumulator is so affected that about 30 per cent. of its charge is not available, and in subsequent cycles it shows a diminished capacity and efficiency; and that by repeated charges and discharges the capacity may be partially restored and the efficiency more completely so. These changes might be due to—(*a*) leakage or shortcircuit, (*b*) some of the active material having fallen to the bottom of the cell, or (*c*) some change in the active materials. (*a*) is excluded by the fact that the subsequent charge is smaller, and (*b*) by the continued increase of capacity during the cycles that follow the rest. Hence the third hypothesis is the one which must be relied upon. The change in the active materials has already been given. The formation of lead sulphate (on both plates) explains the loss of energy shown in Fig. 24, while the fact that it is probably formed, not in the path of the regular currents, but on the wall of the grid (remote from the ordinary action), gives a probable explanation of the subsequent slow recovery. The action of the acid on the lead during rest must not be overlooked.

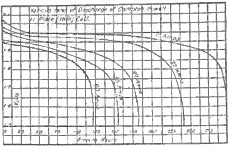


Fig 28

We have seen that capacity diminishes as the discharge rate increases; that is, the available output increases as the current diminishes. Crompton's diagram illustrating this fact is given in Fig. 28. At the higher rates the consumption of acid is too rapid, diffusion cannot maintain its strength in the pores, and the fall comes so much earlier. The resistance varies with the condition of the cell, as shown by the curves in Fig. 29. It may be unduly increased by long or narrow lugs, and especially by dirty joints between the lugs.

It is interesting to note that it increases at the end of both charge and discharge, and much more for the first than the second. Now the composition of the active materials near the end of charge is almost exactly the same as at the beginning of discharge, and at first sight there seems nothing to account for the great fall in resistance from 0·0115 to 0·004 ohm; that is, to about one-third the value. There is, however, one difference between charging and discharging—namely, that due to the strong acid near the positive, with a corresponding weaker acid near the negative electrode. The curve of conductivity for sulphuric acid shows that both strong and weak acid have much higher resistances than the liquid usually employed in accumulators, and it is therefore reasonable to suppose that local variations in strength of acid cause the changes in resistance. That these are not due to the constitution of the plugs is shown by the fact that, while the plugs are almost identical at end of discharge and beginning of charge, the resistance falls from 0·0055 to 0·0033 ohm.

---

[1] This discharge is here compared with the charge that preceded the rest; in the next line the same discharge is compared with the charge following the rest.

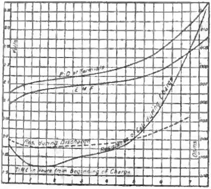


Fig. 29

Temperature of cell.

While a current flows through a cell, heat is produced at the rate of $C^2R \times \cdot 24$ calories (water-gram-degree) per second. As a consequence the temperature tends to rise. But the change of temperature actually observed is much greater during charge, and much less during discharge, than the foregoing expression would suggest; and it is evident that, besides the heat produced according to Joule's law, there are other actions which warm the cell during charge and cool it during discharge. Messrs. Duncan and Wiegand (*loc. cit.*), who first observed the thermal changes, ascribe the chief influence to the electro-chemical addition of H_2SO_4 to the liquid during charge and its removal during discharge. Fig. 30 gives some results obtained by Ayrton, Lamb, &c. This elevation of temperature (due to electrolytic strengthening of acid and local action) is a measure of the energy lost in a cycle, and ought to be minimized as much as possible.

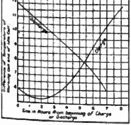


Fig. 30

Chemistry.

The chemical theory which has been adopted in the foregoing pages is very simple. It declares that sulphate of lead is formed on *both* plates in discharge, the chemical action being reversed in charge. Most of the other actions—associated with variations in the E.M.F. of the cell—arise from local variations in strength of acid brought about by chemical action and the electrolysis of the acid. It will contribute to a clear understanding if the chemical actions be considered under various heads:—(1) Those occurring during ordinary charge and discharge; (2) the cause of high E.M.F. at end of charge; (3) the rapid fall of E.M.F. and P.D. at end of discharge; (4) the rapid recuperation of a discharged cell when allowed to repose; (5) the effect of repose on a charged cell; and (6) the agreement of the experimental E.M.F. and that calculated by the Kelvin-Helmholtz thermodynamic equation.

(1) Planté thought that the chemical action during charge and discharge was due to electrolytic hydrogen and oxygen simply. He ignored the chemical action of the acid. In 1882 Gladstone and Tribe published a series of papers, showing, by analyses, that sulphate of lead was formed on both plates, the action being, before discharge,

$$\overset{+\ \text{plate.}}{x.\ PbO_2} + \overset{\text{Liquid.}}{\begin{bmatrix} y.\ H_2SO_4 \\ +n.\ H_2O \end{bmatrix}} + \overset{-\ \text{plate.}}{z.\ Pb}$$

and after discharge

$$\overset{+\ \text{plate.}}{\begin{bmatrix} (x-p)PbO_2 \\ +p.\ PbSO_4 \end{bmatrix}} + \overset{\text{Liquid.}}{\begin{bmatrix} (y-2p)H_2SO_4 \\ (n+2p)H_2O \end{bmatrix}} + \overset{-\ \text{plate.}}{\begin{bmatrix} (z-p)Pb \\ +p.\ PbSO_4 \end{bmatrix}}$$

These results are in harmony with Gladstone and Tribe's analyses, which showed that in every case some of the active material remained unchanged. During charge, the substances are restored to their original condition, and the equation must be reversed. The theory received abundant confirmation—from Frankland in 1883, Reynier (1884), Crova and Garbe (1885), Tchelltzow (1886), Heim and Kohlrausch (1889), Ayrton, &c., with Robertson (1890), Dolezalek (1897), and Mugdan (1899). Notwithstanding this body of evidence it has been objected to, chiefly on the ground that sulphate of lead is a white substance and is difficult to reduce to lead, whereas the substance formed in a cell is not white and is easy to reduce. But Gladstone and Tribe (and afterwards Swinburne) showed in 1883 that sulphate was easy enough to reduce when mixed with other substances like peroxide, or lead itself, which is just the condition in which it occurs in all normal working of the cells. Darrieus suggests that sulphate is formed only on the negative plate, oxide of lead on the positive, and that the spongy lead is in an allotropic condition, which helps to give a higher E.M.F. This theory is contrary to the results obtained by the numerous experimenters already mentioned. Mugdan has especially shown that oxide cannot be detected on the positive plate. It is doubtful if the experiment in favour of an allotropic condition of the lead can be confirmed. The body of evidence in favour of the formation of sulphate on both plates is exceedingly strong—in fact, decisive. Figs. 31 and 32 embody a complete series of chemical and physical observations; many of the preceding statements are illustrated by these curves and can be tested by their relationships. The current was stopped at the points marked A, B, C, D, to take active material for analysis; and the rise of E.M.F. in discharge, and fall in charge, during this short interval is noteworthy.

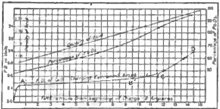


Fig. 31.

(2) Planté attributed the high charging E.M.F. to hydrogen dioxide, and similar oxygenized bodies. Gladstone and Tribe thought that occluded hydrogen and oxygen gases, though very small in quantity, might account for it. Robertson thought that the oxygenized bodies arising from persulphuric acid might raise or lower the E.M.F. according to their exact position in a cell. If, however, these substances are added to a cell (without changing the acid strength) they do not produce a change at all comparable

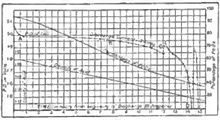


Fig. 32

with that here dealt with, and there is no positive evidence that they will do what is required by the theory. The only known change which has been shown to be competent to affect the E.M.F. to this degree is the change which may locally and temporarily occur in the strength of the acid.[1]

(3) There are two explanations of the rapid fall at the end of discharge. The one already given ascribes the fall to a weakening of the acid in the spongy masses. This has already been considered and need not be further elaborated. The other explanation was first given by Planté, and adopted by Gladstone and Tribe, and afterwards by Robertson. All these workers observed that, at the end of a discharge, patches or small films of peroxide of lead were formed on the surface of the lead plate. Such films speedily tend to annul the E.M.F. and bring the current to zero. Which of these two hypotheses (both representing actual facts and both competent to produce the change under consideration) contributes most to the result is a difficult question. But if a careful comparison be made of the time at which peroxide appears on the negative, with the fall of E.M.F., it will be seen that the fall begins before the films can be detected with certainty. Thus (in Fig. 32) Robertson could not be sure of peroxide on the negative at the point C, although the fall had fairly begun at that time.

(4) The explanation of the rapid recuperation after discharge is that the cause of the rapid fall has ceased and that the conditions existing before it are now re-established. If the discharge fall be ascribed to peroxide films on the negative, then on stopping the discharge the films are destroyed by local action, and the E.M.F. is restored. If the fall be due to exhaustion of acid, then stopping the current allows acid to diffuse into the pores almost instantly, and so restores the E.M.F. If the discharge has not been carried too far, this is most probably the true cause. If the potential difference is below 1·8 volt, both actions take place.

(5) As to the effect of repose on a charged cell, Gladstone and Tribe's experiments showed that peroxide of lead lying on its lead support suffered from a local action, which reduced one molecule of PbO_2 to sulphate at the same time that an atom of the grid below it was also changed to sulphate. There is thus not only a loss of the available peroxide, but a corrosion of the grid or plate. It is through this action that the supports gradually give way. On the negative plate an action arises between the finely-divided lead and the sulphuric acid, with the result that hydrogen is set free.

$$Pb + H_2SO_4 = PbSO_4 + H_2.$$

This involves a diminution of available spongy lead, or loss of capacity, occasionally with serious consequences. The capacity of the lead plate is reduced absolutely, of course, but its relative value is more seriously affected. In the discharge it gets sulphated too much, because the better positive keeps up the E.M.F. too long. In the succeeding charge, the positive is fully charged before the negative, and the differences between them tend to increase in each cycle.

(6) Kelvin and Helmholtz have shown that the E.M.F. of a voltaic cell can be calculated from the energy developed by the chemical action. For a dyad gram equivalent (=2 grams of hydrogen, 207 grams of lead, &c.), the equation connecting them is

$$E = \frac{H}{46000} + T\frac{dE}{dT}$$

where E is the E.M.F. in volts, H is the heat developed by a dyad equivalent of the reacting substances, T is the absolute temperature, and $\frac{dE}{dT}$ is the temperature coefficient of the E.M.F. If the E.M.F. does not change with temperature, the second term is zero. The thermal values for the various substances formed and decomposed are:—For PbO_2, 62400; for $PbSO_4$, 216210; for H_2SO_4, 192920; and for H_2O, 68400 calories. Writing the equation in its simplest form for strong acid, and ignoring the temperature coefficient term,

$$\begin{matrix} PbO_2 + 2H_2SO_4 + Pb = 2PbSO_4 + 2H_2O \\ -62440 - 385840 \qquad\qquad +432420 + 136720 \end{matrix}$$

leaving a balance of 120860 calories. Dividing by 46000 gives 2·627 volts. The experimental value in strong acid, according to Gladstone and Hibbert, is 2·607 volts, a very close approximation. For other strengths of acid, the energy will be less by the quantity evolved when the acid is diluted. The dotted curve in Fig. 11 indicates the calculated E.M.F. at various points when this is taken into account. The difference between it and the continuous curve must, if the chemical theory be correct, depend on the second term in the equation. The figure shows that the observed E.M.F. is above the theoretical for all strengths from 100 down to 5 per cent. Below 5 the position is reversed. The question remains, Can the temperature coefficient be obtained? This is difficult, because the value is so small and it is not easy to secure a good cycle of observations. Streintz has given the following values:—

E	1·9223	1·9828	2·0031	2·0084	2·0105	2·078	2·2070
$\frac{dE}{dT}\cdot 10^6$	140	228	335	285	255	130	73

These figures illustrate the difficulty of getting good determinations; it is quite improbable that cells so nearly alike as those giving 2·003 and 2·008 volts should have temperature coefficients differing by 16 per cent. Unpublished experiments by the writer give $\frac{dE}{dT}\cdot 10^6 = 350$ for acid of density 1·156. With stronger acid, a true cycle could not be obtained. Taking Streintz's value, 335 for 25 per cent. acid, the second term of the equation is $T\frac{dE}{dT} = 290 \times$ ·000335 = 0·0971 volt. The first term gives 88800 calories = 1·9304 volt. Adding the second term, 1·9304 + 0·0971 = 2·0275 volts. The observed value is 2·030 volts (see Fig. 11 and table 2), a remarkably good agreement. This calculation and the general relation shown in Fig. 11 render it highly probable that, if the temperature coefficient were known for all strengths of acid, the result would be equally good. It is worth observing that the reversal of relationship between the observed and calculated curves, which takes place at 5 or 6 per cent., suggests that the chemistry must be on the point of altering as the acid gets weak, a conclusion which has been already arrived at on purely chemical grounds. The thermodynamical relations are thus seen to confirm very strongly the chemical and physical analyses.[2]

Accumulators in central stations.

As the efficiency of accumulators is not generally higher than 75 per cent., and machines must be used to charge them, it is not directly economical to use cells alone for public supply. Yet they play an important and an increasing part in public work, because they help to maintain a constant voltage on the mains, and can be used to distribute the load on the running machinery over a much greater fraction of the day. Used in parallel with the dynamo, they quickly yield current when the load increases, and immediately begin to charge when the load diminishes, thus largely reducing the fluctuating stress on dynamo and engine for sudden variations in load. Their use is advantageous if they can be charged and discharged at a time when the steam plant would otherwise be working at an uneconomical load.

Regulation of the potential difference is managed in various ways. More cells may be thrown in as the discharge proceeds, and taken out during charge; but this method often leads to trouble, as some cells get unduly discharged, and the unity of the battery is disturbed. Sometimes the number of cells is kept fixed for supply, but the P.D. they put on the mains is reduced during charge by employing regulating cells in opposition. The working cells are then all kept in similar condition. But these methods are now being discarded. The number of cells is now fixed and the battery joined to the mains. The heaviest part of the load is shared by battery and dynamo, and after the evening's discharge the dynamo may charge the cells. But they must be charged to a higher potential difference than that kept on the mains, otherwise they cannot be said to be brought back to good condition. This may be done by disconnecting the battery and charging from a dynamo which gives the requisite higher E.M.F.; or it may be done (and this is usual) by taking the current from the mains to the battery through a "booster," that is, a dynamo arranged so that its E.M.F. is added to that of the mains. The power requisite for driving its armature may be obtained from any convenient source, but it is most usual to couple the armature to the shaft of a motor driven from the mains.

There are certain disadvantages in carrying accumulators on tramcars. The cells add largely to the weight of the car; there is much expense in handling, owing to the substitution of charged for discharged cells every few hours; and there is a very rapid deterioration of the plates, consequent upon shaking and the heavy starting currents. For these reasons the use of cells on the cars has not generally been a commercial success, though at the present time a few lines are being run. The following table gives some particulars of two systems worked by "chloride" cells:—

---

[1] Gladstone and Hibbert, *Phil. Mag.* 1890; *Jour. Inst. Elec. Eng.* 1892. Dolezalek, *Ann. Phys. Chem.* 1898. Mugdan, *Elekt. Zeitschrift*, 1899.

[2] For the discussion of later electrolytic theories as applied to accumulators, see *Electro-chemistry* by Le Blanc; also an article by Hoppe, *Elektrotech. Runds.* 1898.

Tramways.

Items.	Birmingham.	Paris.
Weight of battery in pounds . . .	6048	6615
Average discharge in amperes during run	50	35
Maximum discharge during run . .	120-150	100-120
Length of run with one charge in miles .	45	37
Speed in miles	8 to 15	8 to 15
No. of passengers carried . . .	50	50

At Birmingham some cells have completed 20,000 car miles before renewal was necessary. Cost of renewal per car mile is approximately $1\frac{5}{8}$ penny. But if the accumulators be used in the central or a sub-station, there are many advantages. In a traction station the load varies so rapidly that the plant is generally working at a low average load factor; and the machinery must be capable of meeting the maximum demand, while the average load does not exceed one-half of the maximum. Now accumulators will take the peaks of the load, relieving the machinery from sudden jerks, and further allowing the running plant to be reduced to that which suffices for the average load. Some idea of the significance of this may be gained from Fig. 33.

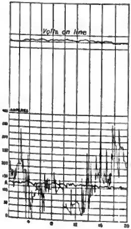


Fig. 33.

The cells are in parallel with the generator. Eight cars were running. The thick line A shows the dynamo current, varying from 115 to 150 amperes. The line current varies from 0 to 375 amperes. It is evident that engine and generator are kept fully loaded, the cells supplying the peaks and taking a charge during the hollow. For work like this, the cells ought to have a low resistance, and it is desirable that the shunt-wound dynamo shall have a falling characteristic. Compound-wound boosters are sometimes used to help the accumulators to share the load. Fig. 34 is a diagram of the arrangement. The following data illustrate the way in which accumulators are employed in the station belonging to the Plymouth Corporation. Alternate current is used for lighting and continuous current for the tramway line. There are two combined sets; that is, engine, alternator, and tramway generator coupled on the same shaft. Other and larger alternators are in use during the "peak" of the load. In the combined sets the alternator and generator are each 100 kilowatt machines; the Belliss engine is 150 B.H.P. The engine is therefore only large enough to drive either of the machines at full load, but can run both at any combination of load not greater than 100 K.W. total. The generator gives 535 volts, and is in parallel with 260 cells of the Tudor type. The cars begin to run at 7.30 A.M. The cells and one generator are in parallel sharing the tramway load through the day, with results very similar to those shown in Fig. 33. The alternator on the same shaft supplies the small day lighting load. When the evening lighting load comes on, the direct current generators are uncoupled, the accumulators take the tramway work, and the total engine power is available for running the fully-loaded alternators. This continues till the cars stop at 11 o'clock, by which time the lighting load has gone down again. The pressure of the cells has diminished from 520 to 475 volts. A generator is now coupled up and charges the accumulators from 11 P.M. to 2.30 or thereabouts; a booster adding from 70 to 130 volts, as may be required. The booster motor takes from 15 to 20 amperes at 530 volts, depending on the output from its dynamo. These arrangements give a well-distributed load and economical conditions of working for such machinery as is at any time running, while the cells are a stand-by for exciting plant, &c.

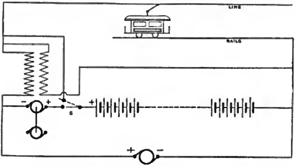


Fig. 34.

The following books and papers may be consulted in addition to those already cited:—

Planté. *Recherches sur l'Électricité.* Paris, 1879.—Gladstone and Tribe. *Chemistry of Secondary Batteries.* London, 1884.—Reynier. *L'Accumulateur Voltaïque.* Paris, 1888.—Heim. *Die Akkumulatoren.* Berlin, 1889.—Hoppe. *Die Akkumulatoren für Elektricität.* Berlin, 1892.—Schoop. *Handbuch für Akkumulatoren.* Stuttgart, 1898.—Frankland. "Chemistry of Storage Batteries," *Proc. Roy. Soc.* 1883.—Reynier. "Essai sur la Théorie Chimique des Accumulateurs," *Jour. Soc. Franç. d. Phys.* 1884.—Heim. "U. d. Einfluss der Säuredichte auf die Kapazitat der Akk.," *Elek. Zeits.* 1889.—Kohlrausch u. Heim. "Ergebnisse von Versuchen an Akk. für Stationsbetrieb," *Elek. Zeits.* 1889.—Darricus. "La Théorie Chimique des Accumulateurs Plomb.," *Bull. Soc. Intern. des Électriciens,* 1892.—E. J. Wade. *Secondary Batteries.* London, 1901.

(W. Ht.)

Acetylene, klumene or ethine, is one of the gaseous compounds of hydrogen and carbon, and on analysis is found to contain—

Carbon	92·3
Hydrogen	7·7
	100·0

The molecule is represented by the formula C_2H_2. It is a clear, colourless gas, having a density of 0·92. When prepared by the action of water upon calcium carbide, it has a very strong and penetrating odour, but when it is thoroughly purified from sulphuretted and phosphuretted hydrogen, which are invariably present with it in minute traces, this extremely

Physical properties.

pungent odour disappears, and the pure gas has a not unpleasant etherial smell. It can be condensed into the liquid state by cold or by pressure, and experiments by Ansell show that if the gas be subjected to a pressure of 21·53 atmospheres at a temperature of 0° C., it is converted into the liquid state, the pressure needed increasing with the rise of temperature, and decreasing with the lowering of the temperature, until at – 82° C. it becomes liquid under ordinary atmospheric pressure. The critical point of the gas is 37° C., at which temperature a pressure of 68 atmospheres is required for liquefaction. A great future was expected from its use in the liquid state, since a cylinder fitted with the necessary reducing valves would supply the gas to light a house for a considerable period, the liquid occupying about $\frac{1}{400}$ the volume of the gas, but in the United States and on the Continent of Europe, where liquefied acetylene was made on the large scale, several fatal accidents occurred owing to its explosion under not easily explained conditions. As a result of these accidents Berthelot and Vieille made a series of valuable researches upon the explosion of acetylene under various conditions. They found that if liquid acetylene in a steel bottle be heated at one point by a platinum wire raised to a red heat, the whole mass decomposes and gives rise to such tremendous pressures that no cylinder would be able to withstand them. These pressures varied from 71,000 to 100,000 lb per square inch. They, moreover, tried the effect of shock upon the liquid, and found that the repeated dropping of the cylinder from a height of nearly 20 feet upon a large steel anvil gave no explosion, but that when the cylinder was crushed under a heavy blow the impact was followed, after a short interval of time, by an explosion which was manifestly due to the fracture of the cylinder and the ignition of the escaping gas, mixed with air, from sparks caused by the breaking of the metal. A similar explosion will frequently follow the breaking in the same way of a cylinder charged with hydrogen at a high pressure. Continuing these experiments, they found that in acetylene gas under ordinary pressures the decomposition brought about in one portion of the gas, either by heat or the firing in it of a small detonator, did not spread far beyond the point at which the decomposition started, while if the acetylene was compressed to a pressure of more than 30 lb on the square inch, the decomposition travelled throughout the mass and became in reality detonation. These results showed clearly that liquefied acetylene was far too dangerous for general introduction for domestic purposes, since, although the occasions would be rare in which the requisite temperature to bring about detonation would be reached, still, if this point were attained, the results would be of a most disastrous character. The fact that several accidents had already happened accentuated the risk, and in Great Britain the storage and use of liquefied acetylene are prohibited.

Liquefaction.

Explosibility of liquid acetylene.

Solid acetylene.

When liquefied acetylene is allowed to escape from the cylinder in which it was contained into ordinary atmospheric pressure, some of the liquid assumes the gaseous condition with such rapidity as to cool the remainder below the temperature of – 90° C., and convert it into a solid snow-like mass.

Solubility of acetylene.

Acetylene is readily soluble in water, which at normal temperature and pressure takes up a little more than its own volume of the gas, and yields a solution giving a purple-red precipitate with ammoniacal cuprous chloride and a white precipitate with silver nitrate, these precipitates consisting of acetylides of the metals. The solubility of the gas in various liquids, as given by different observers, is—

100 Volumes of		Volumes of Acetylene.
Brine	absorb	5
Water	,, . . .	110
Alcohol	,, . . .	600
Paraffin	,, . . .	150
Carbon disulphide	,, . . .	100
Fusel oil	,, . . .	100
Benzene	,, . . .	400
Chloroform	,, . . .	400
Acetic acid	,, . . .	600
Acetone	,, . . .	3100

Solution in acetone.

It will be seen from this table that where it is desired to collect and keep acetylene over a liquid, brine, *i.e.*, water saturated with salt, is the best for this purpose, but in practice it is found that, unless water is agitated with acetylene, or the gas bubbled through, the top layer soon gets saturated and the gas then dissolves but slowly. The great solubility of acetylene in acetone was pointed out by MM. Claude and Hess, who suggested charging acetone with the gas under pressure, a litre of acetone dissolving 360 times its own volume of the gas under a pressure of 12 atmospheres. When the pressure is relieved the gas again escapes, and it was thought that in this way a better method of storing the gas would be provided by liquefaction. Experiment, however, has shown that acetone thus saturated under pressure shares many of the disadvantages of liquid acetylene itself.

Explosive compounds with metals.

When acetylene was first introduced on a commercial scale grave fears were entertained as to its safety, it being represented that it had the power of combining with certain metals, more especially copper and silver, to form acetylides of a highly explosive character, and that even with coal gas, which contains less than 1 per cent., such copper compounds had been known to be formed in cases where the gas distributing mains were composed of copper, and that accidents had happened from this cause. It was therefore predicted that the introduction of acetylene on a large scale would be followed by numerous accidents unless copper and its alloys were rigidly excluded from contact with the gas. These fears have, however, fortunately proved to be unfounded, and ordinary gas fittings can be used with perfect safety with this gas.

Poisonous properties.

Acetylene was at one time supposed to be a highly poisonous gas, the researches of Bistrow and Liebreich having apparently shown that it acts upon the blood in the same way as carbon monoxide to form a stable compound. Very extensive experiments, however, made by Drs Grehant, Brociner, Malooz, Crismer, and others, all conclusively show that acetylene is much less toxic than carbon monoxide and indeed than coal gas.

Chemical actions.

Acetylene has the property of inflaming spontaneously when brought in contact with chlorine. If a few pieces of carbide be dropped into saturated chlorine water the bubbles of gas take fire as they reach the surface, and if a jet of acetylene be passed up into a bottle of chlorine it takes fire and burns with a heavy red flame, depositing its carbon in the form of soot. If chlorine be bubbled up into a jar of acetylene standing over water, a violent explosion, attended with a flash of intense light and the deposition of carbon, at once takes place. When the gas is kept in a small glass holder exposed to direct sunlight, the surface of the glass soon becomes dimmed, and Bone has shown that when exposed for some time to the sun's rays it undergoes certain polymerization changes which lead to the deposition of a film of heavy hydrocarbons on the surface of the tube.

Acetylene as a starting-point in synthesis.

It has also been observed by Cailletet and later by Villard that when allowed to stand in the presence of water at a low temperature a solid hydrate is formed. Acetylene is readily decomposed by heat, polymerizing under its influence to form an enormous number of organic compounds; indeed the gas, which can itself be directly prepared from its constituents, carbon and hydrogen, under the influence of the electric arc, can be made the starting-point for the construction of an enormous number of different organic compounds of a complex character. In contact with nascent hydrogen it builds up ethylene; ethylene acted upon by sulphuric acid yields sulphovinic acid; this can again be decomposed in the presence of water to yield alcohol, and it has also been proposed to manufacture sugar from this remarkable body. Picric acid can also be obtained from it by first treating acetylene with sulphuric acid, converting the product into phenol by solution in potash, and then treating the phenol with fuming nitric acid.

Detonation.

Ignition point.

Combustion.

Explosive mixtures.

Acetylene is one of those bodies the formation of which is attended with the disappearance of heat, and it is for this reason termed an "endothermic" compound, in contra-distinction to those bodies which evolve heat in their formation, and which are called "exothermic." Such endothermic bodies are nearly always found to show considerable violence in their decomposition as the heat of formation stored up within them is then liberated as sensible heat, and it is undoubtedly this property of acetylene gas which leads to its easy detonation by either heat or a shock from an explosion of fulminating mercury when in contact with it under pressure. The observation that acetylene can be resolved into its constituents by detonation is due to Berthelot, who started an explosive wave in it by firing a charge of 0·1 gram of mercury fulminate. It has since been shown, however, that unless the gas is at a pressure of more than two atmospheres this wave soon dies out, and the decomposition is only propagated a few inches from the detonator. Heated in contact with air to a temperature of 480° C. acetylene ignites and burns with a flame, the appearance of which varies with the way in which it is brought in contact with the air. With the gas in excess a heavy lurid flame emitting dense volumes of smoke results, whilst if it be driven out in a sufficiently thin sheet, it burns with a flame of intense brilliancy and almost perfect whiteness, by the light of which colours can be judged as well as they can by daylight. Having its ignition point below that of ordinary gas, it can be ignited by any red-hot carbonaceous matter, such as the brightly glowing end of a cigar. For its complete combustion a volume of acetylene needs approximately twelve volumes of air, forming as products of combustion carbon dioxide and water vapour. When, however, the air is present in much smaller ratio the combustion is incomplete, and carbon, carbon monoxide, carbon dioxide, hydrogen, and water vapour are produced. This is well shown by taking a cylinder one-half full of acetylene and one-half of air; on applying a light to the mixture a lurid flame runs down the cylinder and a cloud of soot is thrown up, the cylinder also being thickly coated with it, and often containing a ball of carbon. If now, after a few moments' interval to allow some air to diffuse into the cylinder, a taper again be applied, an explosion takes place, due to a mixture of carbon monoxide and air. It is probable that when a flame is smoking badly, distinct traces of carbon monoxide are being produced, but when an acetylene flame burns properly the products are as harmless as those of coal gas, and, light for light, less in amount. Mixed with air, like every other combustible gas, acetylene forms an explosive mixture. Clewes has shown that it has a wider range of explosive proportions when mixed with air than any of the other combustible gases, the limiting percentages being as follows:—

Acetylene	3 to 82
Hydrogen	5 to 72
Carbon monoxide	13 to 75
Ethylene	4 to 22
Methane	5 to 13

Methods of production.

Manufacture of calcium carbide.

The methods which can be and have been employed from time to time for the formation of acetylene in small quantities are exceedingly numerous. Before the commercial production of calcium carbide made it one of the most easily obtainable gases, the processes which were most largely adopted for its preparation in laboratories were:—first, the decomposition of ethylene bromide by dropping it slowly into a boiling solution of alcoholic potash, and purifying the evolved gas from the volatile bromethylene by washing it through a second flask containing a boiling solution of alcoholic potash, or by passing it over moderately heated soda lime; and, second, the more ordinarily adopted process of passing the products of incomplete combustion from a Bunsen burner, the flame of which had struck back, through an ammoniacal solution of cuprous chloride, when the red acetylide of copper was produced. This on being washed and decomposed with hydrochloric acid yielded a stream of acetylene gas. This second method of production has the great drawback that, unless proper precautions are taken to purify the gas obtained from the copper acetylide, it is always contaminated with certain chlorine derivatives of acetylene. Edmund Davy first made acetylene in 1836 from a compound produced during the manufacture of potassium from potassium tartrate and charcoal, which under certain conditions yielded a black compound decomposed by water with considerable violence and the evolution of acetylene. This compound was afterwards fully investigated by Berzelius, who showed it to be carbide of potassium. He also made the corresponding sodium compound and showed that it evolved the same gas, whilst in 1862 Wöhler first made carbide of calcium, and found that water decomposed it into lime and acetylene. It was not, however, until 1892 that the almost simultaneous discovery was made by Willson in America and Moissan in France that if lime and carbon be fused together at the temperature of the electric furnace, the lime is reduced to calcium, which unites with the excess of carbon present to form calcium carbide. The cheap production of this material and the easy liberation by its aid of acetylene at once gave the gas a position of commercial importance. In the manufacture of calcium carbide in the electric furnace, lime and hard metallurgical coke of the highest possible degree of purity are employed. A good working mixture of these materials may be taken as being 100 parts by weight of lime with 68 parts by weight of carbonaceous material. About 1·8 ℔ of this is used up for each pound of carbide produced. The two principal processes utilized in making calcium carbide by electrical power are the ingot process and the tapping process. In the former, the coke and lime are finely ground and carefully mixed in the right proportions to suit the chemical actions involved. The arc is struck in a crucible into which the powdered mixture is allowed to flow, partially filling it. An ingot gradually builds up from the bottom of the crucible, the carbon electrode being raised from time to time automatically or by hand to suit the diminution of resistance due to the shortening of the arc by the rising ingot. The

"Ingot" carbide.

"Run" carbide.

crucible is of metal and considerably larger than the ingot, the latter being surrounded by a mass of unreduced material which protects the crucible from the intense heat. When the ingot has been made and the crucible is full, the latter is withdrawn and another substituted. The process is not continuous, but a change of crucibles only takes two or three minutes under the best conditions, and only occurs every ten or fifteen hours. The essence of this process is that the coke and lime are only heated to the point of combination, and are not "boiled" after being formed. It is found that the ingot of calcium carbide formed in the furnace, although itself consisting of pure crystalline calcium carbide, is nearly always surrounded by a crust which contains a certain proportion of imperfectly converted constituents, and therefore gives a lower yield of acetylene than the carbide itself. In breaking up and sending out the carbide for commercial work, packed in air-tight drums, the worst of the crust is as far as possible picked out and rejected. A statement of the amount made per kilowatt hour may be misleading, since a certain amount of loss is of necessity entailed during this process. For instance, in practical working it has been found that a furnace return of 0·504 lb per kilowatt hour is brought down to 0·406 lb per kilowatt hour when the material has been broken up, sorted, and packed in air-tight drums. In the tapping process a fixed crucible is used, lined with carbon, the electrode is nearly as big as the crucible, and a much higher current density is used. Fine grinding is unnecessary, as combination probably only takes place after fusion of the raw materials which mix more or less as liquids. The carbide is heated to complete liquefaction and tapped at short intervals. There is no unreduced material, and the process is considerably simplified, while less expensive plant is required. The run carbide, however, is never so rich as the ingot carbide, since an excess of lime is nearly always used in the mixture to act as a flux, and this remaining in the carbide lowers its gas-yielding power. Many attempts have been made to produce the substance without electricity, but have met with no commercial success.

Properties of calcium carbide.

Carbide of calcium, as formed in the electric furnace, is a beautiful crystalline semi-metallic solid, having a density of 2·22, and showing a fracture which is often shot with iridescent colours. It can be kept unaltered in dry air, but the smallest trace of moisture in the atmosphere leads to the evolution of minute quantities of acetylene and gives it a distinctive odour. It is infusible at temperatures up to 2000° C., but can be fused in the electric arc. When heated to a temperature of 245° C. in a stream of chlorine gas it becomes incandescent, forming calcium chloride and liberating carbon, and it can also be made to burn in oxygen at a dull red heat, leaving behind a residue of calcium carbonate. Under the same conditions it becomes incandescent in the vapour of sulphur, yielding calcium sulphide and carbon disulphide; the vapour of phosphorus will also unite with it at a red heat. It is a compound of

Calcium	62·5 per cent.
Carbon	37·5
	100·0

The yield from calcium carbide.

Impurities.

Acted upon by water it is at once decomposed, yielding acetylene and calcium hydrate. Pure crystalline calcium carbide yields 5·8 cubic feet of acetylene per pound at ordinary temperatures, but the carbide as sold commercially, being a mixture of the pure crystalline material with the crust which in the electric furnace surrounds the ingot, yields an average of 5 cubic feet of gas per pound under proper conditions of generation. The volume of gas obtained, however, depends very largely upon the form of apparatus used, and while some will give the full 5 cubic feet, other apparatus will only yield, with the same carbide, 3$\frac{3}{4}$ feet. The purity of the carbide entirely depends on the purity of the material used in its manufacture, and before this fact had been fully grasped by manufacturers, and only the purest material obtainable employed, it contained notable quantities of compounds which during its decomposition by water yielded a somewhat high proportion of impurities in the acetylene generated from it. Although at the present time a marvellous improvement has taken place all round in the quality of the carbide produced, the acetylene nearly always contains minute traces of hydrogen, ammonia, sulphuretted hydrogen, phosphuretted hydrogen, siliciuretted hydrogen, nitrogen, and oxygen, and sometimes minute traces of carbon monoxide and dioxide. The formation of hydrogen is caused by small traces of metallic calcium occasionally found free in the carbide, and cases have been known where this was present in such quantities that the evolved gas contained nearly 20 per cent. of hydrogen. This takes place when in the manufacture of the carbide the material is kept too long in contact with the arc, since this overheating causes the dissociation of some of the calcium carbide and the solution of metallic calcium in the remainder. The presence of free hydrogen is nearly always accompanied by siliciuretted hydrogen formed by the combination of the nascent hydrogen with the silicon in the carbide. The ammonia found in the acetylene is due to the presence of magnesium nitride in the carbide. This is formed by the metallic magnesium in the molten condition taking up nitrogen from the air. On decomposition by water ammonia is produced by the action of steam or of nascent hydrogen on the nitride, the quantity formed depending very largely upon the temperature at which the carbide is decomposed. The formation of nitrides by actions of this kind and their easy conversion into ammonia, will probably at some no very distant date prove a useful method for fixing the nitrogen of the atmosphere and rendering it available for manurial purposes, although it could never compete in price with the ammonia formed in the destructive distillation of coal for coal gas. Sulphuretted hydrogen, which is invariably present in commercial acetylene, is formed by the decomposition of aluminium sulphide. Murlot has shown that aluminium sulphide, zinc sulphide, and cadmium sulphide are the only sulphur compounds which can resist the heat of the electric furnace without decomposition or volatilization, and of these aluminium sulphide is the only one which is decomposed by water with the evolution of sulphuretted hydrogen. In the early samples of carbide this compound used to be present in considerable quantity, but now rarely more than $\frac{1}{10}$ per cent. is to be found. Phosphuretted hydrogen, one of the most important impurities, which has been blamed for the haze formed by the combustion of acetylene under certain conditions, is produced by the action of water upon traces of calcium phosphide found in carbide. Although at first it was no uncommon thing to find a half per cent. of phosphuretted hydrogen present in the acetylene, this has now been so reduced by the use of pure materials that the average quantity is rarely above 0·15 per cent., and it is often not one-fifth of that amount.

Generation of acetylene from carbide.

In the generation of acetylene from calcium carbide and water, all that has to be done is to bring these two compounds into contact, when they mutually react upon each other with the formation of lime and acetylene, while, if there be sufficient water present, the lime combines with it to form calcium hydrate.

$$1.\quad \overset{\text{Calcium carbide.}}{CaC_2} + \overset{\text{Water.}}{H_2O} = \overset{\text{Acetylene.}}{C_2H_2} + \overset{\text{Lime.}}{CaO.}$$

$$2.\quad \overset{\text{Lime.}}{CaO} + \overset{\text{Water.}}{H_2O} = \overset{\text{Calcium hydrate.}}{Ca(HO)_2.}$$

Every operation, no matter how simple it appears at first sight, is capable of being performed in several ways, and decomposition of the carbide by water may be brought about either by bringing the water slowly into contact with an excess of carbide, or by dropping the carbide into an excess of water, and these two main operations again may be varied by innumerable ingenious devices by which the rapidity of the contact may be modified or even eventually stopped. The result is that although the forms of apparatus utilized for this purpose are all based on the one fundamental principle of bringing about the contact of the carbide with the water which is to enter into double decomposition with it, they have been multiplied in number to a very large extent by the methods employed in order to ensure control in working, and to get away from the dangers and inconveniences which are inseparable from a too rapid generation.

Generators.

In attempting to classify acetylene generators some authorities have divided them into as many as six different classes, but this is hardly necessary, as they may be divided into two main classes:—first, those in which water is brought in contact with the carbide, the carbide being in excess during the first portion of the operation; and, second, those in which the carbide is thrown into water, the amount of water present being always in excess. The first class may again be subdivided into generators in which the water rises in contact with the carbide, in which it drips upon the carbide, and in which a vessel full of carbide is lowered into water, and again withdrawn as generation becomes excessive. Some of these generators are constructed to make the gas only as fast as it is consumed at the burner, with the object of saving the expense and room which would be involved by a storage-holder. Generators with devices for regulating and stopping at will the action going on are generally termed "automatic." Another set merely aims at developing the gas from the carbide and putting it into a storage-holder with as little loss as possible, and these are termed "non-automatic." The points to be attained in a good generator are:—

1. Low temperature of generation.
2. Complete decomposition of the carbide.
3. Maximum evolution of the gas.
4. Low pressure in every part of the apparatus.
5. Ease in charging and removal of residues.
6. Removal of all air from the apparatus before generation of the gas.

When carbide is acted upon by water considerable heat is evolved; indeed, the action develops about one-twentieth of the heat evolved by the combustion of carbon. As, however, the temperature developed is a function of the time needed to complete the action, the degree of heat attained varies with every form of generator, and while the water in one form may never reach the boiling-point, the carbide in another may become red-hot and give a temperature of over 800° C. Heating in a generator is not only a source of danger, but also lessens the yield of gas and deteriorates its quality. The best forms of generator are either those in which water rises slowly in contact with the carbide, or the second main division in which the carbide falls into excess of water.

It is clear that acetylene, if it is to be used on a large scale as a domestic illuminant, must undergo such processes of purification as will render it harmless and innocuous to health and property, and the sooner it is recognized as absolutely essential to purify acetylene before consuming it the sooner will the gas acquire the popularity it deserves. The only one of the impurities which offers any difficulty in removal is the phosphuretted hydrogen. There are three substances which can be relied on more or less to remove this compound, and the gas to be purified may be passed either through acid copper salts, through bleaching powder, or through chromic acid. In experiments with these various bodies it is found that they are all of them effective in also ridding the acetylene of the ammonia and sulphuretted hydrogen, provided only that the surface area presented to the gas is sufficiently large. The method of washing the gas with acid solutions of copper has been patented by Herr A. Frank of Charlottenburg, who finds that a concentrated solution of cuprous chloride in an acid, the liquid being made into a paste with kieselgühr, is the most effective. Where the production of acetylene is going on on a small scale this method of purification is undoubtedly the most convenient one, as the acid present absorbs the ammonia, and the copper salt converts the phosphuretted and sulphuretted hydrogen into phosphates and sulphides. The vessel, however, which contains this mixture has to be of earthenware, porcelain, or enamelled iron on account of the free acid present; the gas must be washed after purification to remove traces of hydrochloric acid, and care must be taken to prevent the complete neutralization of the acid by the ammonia present in the gas. The second process is one patented by Dr Ullmann of Geneva, who utilizes chromic acid to oxidize the phosphuretted and sulphuretted hydrogen and absorb the ammonia. The third process owes its inception to Lunge, who recommends the use of bleaching powder. Dr Wolff has found that when this is used on the large scale there is a risk of the ammonia present in the acetylene forming traces of chloride of nitrogen in the purifying boxes, and as this is a compound which detonates with considerable local force, it occasionally gives rise to explosions in the purifying apparatus. If, however, the gas be first passed through a scrubber so as to wash out the ammonia this danger is avoided. Dr Wolff employs purifiers in which the gas is washed with water containing calcium chloride, and then passed through bleaching powder solution or other oxidizing material.

Purification.

Illuminating power.

Burners.

When acetylene is burnt from a 000 union jet burner, at all ordinary pressures a smoky flame is obtained, but on the pressure being increased to 4 inches a magnificent flame results, free from smoke, and developing an illuminating value of 240 candles per 5 cubic feet of gas consumed. Slightly higher values have been obtained, but 240 may be taken as the average value under these conditions. When acetylene was first introduced as a commercial illuminant in England, very small union jet nipples were utilized for its consumption, but after burning for a short time these nipples began to carbonize, the flame became distorted, and then smoking occurred with the formation of a heavy deposit of soot. While these troubles were being experienced in England, attempts had been made in America to use acetylene diluted with a certain proportion of air which permitted it to be burnt in ordinary flat flame nipples; but the danger of such admixture being recognized, nipples of the same class as those used in England were employed, and the same troubles ensued. In France, single jets made of glass were first employed, and then Risener, Luchaire, Ragot, and others, made burners in which two jets of acetylene, coming from two tubes placed some little distance apart, impinged and splayed each other out into a butterfly flame. Soon afterwards, Billwiller introduced the idea of sucking air into the flame at or just below the burner tip, and at this juncture the Naphey or Dolan burner was introduced in America, the principle employed being to use two small and widely separated jets instead of the two openings of the union jet burner, and to make each a minute Bunsen, the acetylene dragging in from the base of the nipple enough air to surround and protect it while burning from contact with the steatite. This class of burner has been very successful, and its introduction, together with the realization of the importance of purifying the gas before combustion, has removed perhaps the most important obstacle to the use of this beautiful illuminant.

Authorities.—DOMMER, *L'Acétylène et ses applications.* Paris, 1896.—LEWES, *Acetylene.* London, 1900.—LIEBETANZ, *Calciumcarbid und Acetylen.* Leipzig, 1899.—PELLISSIER, *L'éclairage à l'acétylène.* Paris, 1897.—PERRODIL, *Le carbure de calcium et l'acétylène.* Paris, 1897.—For a complete list of the various papers and memoirs on Acetylene, see Ludwig's *Führer durch die gesammte Calciumcarbid- und Acetylen-Literatur.* Berlin, 1899.

(V. B. L.)

Achill Island, off the west coast of Ireland, part of the county of Mayo. Now under the control of the Congested Districts Board, who have made efforts to improve the condition of the people. There is now a station at Achill Sound, which is crossed by a swivel bridge, opened in 1888. Population, 4677.

Achin (Dutch *Atjeh*) and its dependencies form a government of Northern Sumatra, extending from 2° 53′ N. on the W. coast to 4° 32′ N. on the E. coast. The area of Achin is estimated at 20,520 square miles. Since 1874 the valley of the Achin river has been subjugated by the Dutch. The restriction of export and import to Achin (1888) and further regulation of the ports (1892), the death of the traitor Tuku Umar, and the successful expeditions of General van Heutsz (1898-99) on both coasts and in the valley, have broken resistance and firmly established Dutch government. A scheme to unite the coasts by a railway is under consideration. The administrative divisions are as follows—1. Great Achin (the nine districts within and beyond the military posts) with Poeloe Wai (isle); 2. dependencies (west coast, with the island of Simalu [Babi or Hog], north coast, east coast, and the southern settlements of Great Achin). Under the military and civil chief is a resident (for the regulation of shipping and Achin affairs), and under him again assistant-residents for the dependencies. Geographical knowledge of the Achin valley, river, and coast has been considerably advanced since 1874. In its upper part, near Selimun, the valley is 3 miles broad, the river having a breadth of 99 feet and a depth of 1½ feet; but in its lower course, north of its junction with the Krung Daru, the valley broadens to 12½ miles. The marshy soil is covered by rice-fields, and on higher ground by *kampongs* full of trees. The river at its mouth is 327 feet broad and 20-33 feet deep, but before it lies a sandbank covered at low water by a depth of only 4 feet. The coasts are low and the rivers insignificant, rising in the coast ranges and flowing through the coast states (the chief of which are Pedir, Gighen, and Samalanga on the N., Edi, Perlak, and Langsar on the E., Kluwah, Rigas, and Melahuh on the W.). The chief ports are Olehleh, the port of Kotaraja or Achin (formerly Kraton, now the seat of the Dutch Government), Segli on the N., Edi on the E., and Analabu or Melahuh on the W., all visited by steamers of the Royal Packet Company. The relief of the soil of Achin is imperfectly understood. With regard to the west coast, Resident van Langen has spoken of the Barisan and other parallel ranges which are characteristic of the island of Sumatra, and a geological description of a small portion of the same coast has been given by the mining engineer Renaud, but the interior, possibly a continuation of the Batta plateau, is unexplored. The population of Achin in 1898 was estimated at 535,432, of whom 328 were Europeans, 3933 Chinese, 30 Arabs, and 372 other foreign Asiatics. The natives of this commercial state are of very mixed origin (Hindu, Klings, Malay, Arab). They live in *kampongs*, collections of houses and gardens, which combine to form *mukims* or districts, which again combine to form *sagis*, of which there are three. The chief of a *mukim* is called an *imeum*, of a *sagi* a *panglima sagi*. The people of the highlands (*orang tunong*) differ in many respects from those of the lowlands (*orang baroh*). The means of subsistence are furnished by the culture of rice, betel (penang), tobacco, and pepper, but agriculture and stock-raising both declined during the war. The following industries are of some importance—gold-working, weapon-making, silk-weaving, the making of pottery, fishing and coasting trade. The value of the exports (chiefly pepper) has of late years been about £58,000, of the imports from £165,000 to £250,000.

KRUIJT. *Atjeh en de Atjehers.* Leiden, 1877.—VAN LANGEN. *Atjeh's Westkust, Tijdschrift Aardrijks. Genootsch.* Amsterdam, 1888, p. 226.—RENAUD. *Jaarboek van het Mynwezen.* 1882.—JACOBS *Het familie-en Kampongleven op Groot Atjeh.* Leiden, 1894.—SNOUCK HURGRONJE. *De Atjehers.* Batavia, 1894.

(C. M. K.)

Achinsk, a district town of Russia, East Siberia, government of Yeniseisk, 110 miles by rail W. of Krasnoyarsk, and on the Chulym river. It was founded in 1642, and remained quite insignificant till lately, when steamers began to ply on the Chulym to the gold mines. There are tanneries and soap and candle works. Population (1860), 2501; (1897), 6714.

Achromatic Objectives.—The general equation for two lenses in contact and of negligible thicknesses is,

$$P = A(n-1) + B(n'-1),$$

where P is the power of the combined system, or the reciprocal of its focal length, A and B are the sums of the reciprocals of the radii of curvatures of the first and second lenses respectively, and n and n' are the indices of refraction of the materials of which these two lenses are made. It is obvious that in general the value of P varies with the refrangibility of light, *i.e.*, with its wave-length. The mathematical condition which must obtain in order that the power shall be invariable is that the derivative of this equation shall vanish, or

$$\frac{dP}{dn} = 0 = A + B\frac{dn'}{dn}.$$

Lenses, whether binary or multiple, subject to this condition and employed for the formation of real images are called achromatic objectives. These two equations would serve to determine the values of A and B, when P is assumed, and thus completely solve the problem in its elementary form, were it not unfortunately true that the value of the coefficient $\frac{dn'}{dn}$ (called the dispersive ratio), for all practicable materials is far from constant throughout the range of wave-lengths which are involved in optical images. For example, for the kinds of glass most generally employed for large telescopes, this quantity varies from 1·80 in the extreme red to 2·20 in the extreme violet. The method of fixing upon the most advantageous value to substitute in the second equation was not obvious to the earlier opticians, even to those who produced some of the finest telescopes now in use; but it is easily demonstrated that the value should be that which obtains for light of maximum efficiency for the purpose to which it is to be applied. Thus, for visual use the value of $\frac{dn'}{dn}$ corresponding to a wave-length of about 5600 is best, while for photography with ordinary sensitive plates that for a wave-length of about 4300, a materially larger value, should be substituted.

The variability in the dispersive ratio for different regions of the spectrum gives rise to an imperfection in achromatic combinations, which, immaterial in small lenses, becomes of serious consequence in large telescopes and in spectroscopes. In astronomical telescopes the defect appears as a fringe of colour, properly violet, about bright objects; it also renders such instruments quite unavailable for photography. In spectroscopes it necessitates a continuous change in adjustment from one end of the spectrum to the other. As it constitutes the gravest error in the modern telescope, many efforts have been made during more than a century for its elimination. A review of the success attained necessitates a consideration of other defects to which objectives are subject. These may be tabulated as follows:—

1. Chromatic differences of focal length, or secondary colour.
2. Chromatic differences of spherical aberration.
3. Chromatic differences of magnification.
4. Zonal differences of magnification.
5. Images by reflections which illuminate the field.

All of these are inherent in refracting objectives, and no maker, however skilful, is able wholly to eliminate them. The highest success in designing an objective is only attainable by a due regard to the relative importance of these errors, and an adjustment of them to the purpose to which the instrument is to be applied.

In the table of errors the first is that already considered and shown to be dependent on the optical properties of the materials employed; 3 is not distinguishable from this except in cases where the members of the optical system are separated, as in microscopes and camera objectives, and in some forms of telescope; 5, known as "ghosts" to opticians, is fixed as to number, but the positions of the images can be advantageously restricted. To explain the errors 2 and 4, especially important for our present purpose, another term must be first defined.

When a single lens is used for forming an image of a remote object, it is found that the power of the lens always increases continuously with the distance of the portion used from the axis; in other words, the focal lengths of the concentric zones, into which the lens may be regarded as divided, continuously decrease with their diameters. This phenomenon, whose magnitude depends upon the shape as well as upon the power of the lens, is called spherical aberration. It is easy to see that it would be possible to combine a positive lens of such a shape as to yield a small degree of spherical aberration with a properly formed negative lens, even numerically less in power, so as to give a combination free from aberration for light of a chosen refrangibility. An achromatic combination which meets this condition for remote sources of light is a telescope objective. If free from spherical aberration for yellow light it will still possess aberration for light of less refrangibility, while for shorter wave-lengths it will be over-corrected, or have negative aberration. This property, given as 2 in the table, is quite negligible in telescope objectives constructed of ordinary materials, but in microscopic objectives of high efficiency it becomes by far the most serious error.

The error 4 is illustrated in the preceding paragraph as accompanying spherical aberration. In a combined system it may exist independently of such aberration, and it is especially to be avoided in all instruments in which precision of images at even moderate distances from the axis is desired, such as meridian instruments, heliometers, and in all photographic objectives. The analytical condition for this end is that the sine of the angle of deviation of the light of each zone, in the production of an axial image, shall bear a constant ratio to the diameter of the zone.

The extent of secondary colour error (1 of the table) is pretty nearly independent of the kinds of glass employed, provided that only silicic acid, soda, potash, lime, or oxide of lead enter into the composition of the materials. Fraunhofer seems to have experimented with boracic acid as a partial substitute for silica, but without satisfactory results. The experiments of the eminent Jena glass-makers with phosphate crowns and borate flints are optically highly successful, but unfortunately none of these materials is permanent. Recent experiments by the same makers with a very light flint and a dense crown are more promising, but the chromatic differences of spherical aberration are so great, even when the ratio of focal length to aperture is unduly increased over the customary value, that the gain for astronomical use is problematical. Doubtless the Jena potash crown and a boro-silicate flint make the best binary combination for visual telescopes, although the crown has the great disadvantage of being strongly hygroscopic. A triple combination of ordinary crown and flint with a boro-silicate flint has been used with success, but the necessary increase of focal length, together with the fact that the number of harmful reflections is increased from six, the number of the binary lens, to fifteen, renders the advantage in telescopes of large size questionable. A quadruple cemented combination of ordinary crown and flint with potash crown and boro-silicate flint, is practically perfect for small telescopes, and can be unhesitatingly recommended for spectroscopic use.

In microscope objectives the unrecognized error of chromatic differences of spherical aberration rendered all advance in the improvement of that important aid to scientific research nearly stationary for a third of a century, until Abbe made the brilliant discovery that it is possible to eliminate it by a proper separation of the parts of the optical system. Very summarily stated, his method is this—a front, often quite complex in construction, strongly under-corrected for both colour and sphericity, is increased in power by a back system over-corrected in both particulars to the requisite degree. The character of the image produced is found to vary greatly with the separation of the two systems, so that with successive trials a solution may ultimately be discovered in which the defect in question disappears. It is true that this process necessarily introduces the error 3 in a very marked degree, but this may be practically compensated by employing an ocular with equivalent errors of an opposite sign.

The proper method of designing an objective, after finding the optical constants of the materials which are to be employed, is to deduce the values of A and B from the equations above, and then, assuming a ratio for the two radii of the first lens which experience has shown to approximate to the form desired, find by successive trigonometrical computations (not neglecting thicknesses and separations) the remaining constants of construction which adjust the various errors to the best values for the purposes to which the objective is to be applied. (C. S. H.)

Acid and Alkali Manufacture.—We comprise under this heading the manufacture of the three great mineral acids (sulphuric, hydrochloric, and nitric), and that of the carbonate and hydrate of sodium, from which, however, the manufacture of chlorine and its compounds cannot be entirely separated. The manufacture of acids and alkali, understood as above, is by far the most important of inorganic chemical industries, and occupies the great bulk of the capital and labour employed in that direction. It is, at the same time, the indispensable groundwork of all organic chemical industries, as well as of glass-making, paper-making, and many other branches of human activity. We can here give merely an outline of the progress made in these manufactures during the last twenty-five years, and of their actual state and their prospects for the immediate future.

Sulphuric Acid (comp. *Ency. Brit.* vol. xxii. p. 636).—Nearly all sulphuric acid, in its various states of dilution with water, is still made by the old "lead-chamber process," while all sulphuric anhydride, SO_3, together with its solutions in sulphuric acid, known as fuming or Nordhausen oil of vitriol, is now made by the "contact process." The last-named process is probably destined to supersede the lead-chamber process in the near future for the manufacture of concentrated sulphuric acid, *i.e.*, acid containing 92 per cent. H_2SO_4 and upwards. Acid, however, of less concentration (80 per cent. and below) has so far been made more advantageously by the old process, and this state of affairs will probably continue, at least until the respective patents have run out, especially since the large capital sunk in lead chambers is necessarily looking for some return, and is not likely to be abandoned without a determined struggle.

The first step is common to both processes, viz., the manufacture of more or less dilute sulphur dioxide from elementary sulphur, or from such sulphur compounds as readily act upon atmospheric oxygen with formation of sulphur dioxide (sulphurous anhydride, SO_2). The elementary sulphur is generally native brimstone, though in exceptional cases use is made of the sulphur recovered as a by-product in the manufacture of coal-gas, or from alkali waste, &c. The great bulk of the brimstone of commerce still comes from Sicily (comp. *Ency. Brit.* vol. xxii. p. 634); in comparison with this source of supply, the brimstone obtained in Japan and a few other localities plays but a very secondary part, and the great deposits of sulphur stated to exist in other localities, such as the southern states of North America, Mexico, Daghestan, &c., have not as yet been made available to any considerable extent. The production of sulphur dioxide from elementary sulphur seems a very simple operation; yet room has been left for many improvements made during the last decades by the introduction of continuously working burners, and by the utilization of the heat generated during the process. In most localities brimstone is too expensive an agent for the manufacture of sulphuric acid; in England it is used to a very limited extent for the manufacture of acid free from arsenic, and to a much larger extent in North America and Japan, but hardly at all in other countries. The great bulk of sulphuric acid is made by "roasting" metallic sulphides, principally *pyrites* and *blende*. Pyrites in the pure state, FeS_2, occurs in many countries in large quantities; most of that burned in the United Kingdom comes from Spain, and contains a small quantity of copper which is extracted from the residues ("cinders"). Spanish pyrites is also used in Germany, France, and America, together with the pyrites mined in those countries. Good pyrites contains from 48 to 50 per cent., and exceptionally good, 52 per cent. of sulphur, of which from 1 to 4 per cent. or upwards is left in the cinders. Blende, the most important of zinc ores, contains only about half as much sulphur, which is, moreover, burned off with much more difficulty; but as this has to be done in any case, in order to prepare the ore for the extraction of the metal, and as suitable apparatus has been constructed for the purpose, very large quantities of sulphuric acid are now made from blende, especially in Germany and Belgium, and to some extent also in England and America.

The roasting of pyrites always takes place without using any extraneous fuel, the heat given off by the oxidation of the sulphur and the iron being quite sufficient to carry on the process. If the ore is in pieces of the size of a walnut or upwards, it is roasted in plain "kilns" or "burners," provided with a grating of suitable construction for the removal of the cinders, with a side door in the upper part for charging in the fresh ore on the top of the partially burned ore, and with an arch-shaped roof, from which the burner-gas is carried away in a flue common to a whole set of kilns. The latter are always set in a row of twelve or more, and are one after another charged once or twice a day at appropriate intervals, so that a regular evolution of gas takes place all the day round. By employing suitable precautions, a gas of approximately uniform composition is obtained, containing from 6 to 8 per cent. SO_2, with a little SO_3, and about 12 per cent. of oxygen, which is more than sufficient for converting later all the SO_2 into SO_3 or H_2SO_4. The burning of "smalls" or "dust" was formerly considered much more difficult and incomplete than that of pieces, but this difficulty has been entirely overcome in various ways, principally by the "shelf-burner," originally constructed by Maletra, and by mechanical burners, which were formerly almost entirely confined to America, where the saving of labour is a primary consideration. Quite recently the Herreshoff mechanical burner (developed from a burner constructed many years ago by M'Dougal Bros., of Liverpool) is making its way also in Europe. The roasting of blende is nothing like so easy as that of pyrites, since the heat developed by the oxidation of the zinc sulphide itself is not sufficient for carrying on the process, and external heat must be applied. It is now usually performed by a series of muffles, superposed one over another, so that the whole forms a kind of shelf-burner, with internally heated shelves (the "Rhemania" furnace). This operation is both more costly and more delicate than the roasting of pyrites, but it is now perfectly well understood, and gas is obtained from blende furnaces hardly inferior in quality to that yielded by pyrites kilns. In America, and quite exceptionally also in Europe, mechanical furnaces are used for the roasting of blende.

Both kinds of gas, when issuing from the burner, hold in mechanical suspension a considerable quantity of "flue-dust," which must be removed as far as is practicable before the gas is subjected to further treatment. Flue-dust contains principally ferric oxide, zinc oxide, arsenious and sulphuric acids, and small quantities of the various metals occurring in the raw ore. All the thallium and selenium on the market is obtained from this source. Sometimes the burner-gas is employed directly for the sake of the SO_2 which it contains, principally in the manufacture of "sulphite cellulose" from wood. If it is to be utilized for the manufacture of sulphuric acid, the practice up to the present has been, with few exceptions, to carry it into "lead chambers" (vitriol chambers), which are immense receptacles constructed of sheet-lead burned together without any solder and suitably supported outside by wooden or iron framework. In these the sulphur dioxide acts upon the oxygen contained in the same gas, and upon water introduced as a spray or in the shape of steam, and the reaction $SO_2 + O + H_2O = H_2SO_4$ is brought about. As, however, this reaction of its own accord takes place only to a very small extent, an "oxygen carrier" is always introduced in the shape of the vapours of nitric acid or the lower oxides of nitrogen. By the play of reactions induced in this way, practically the whole of the SO_2 is ultimately converted into sulphuric acid, and at the same time the nitrogen oxides are always recovered with comparatively very slight losses and made to serve over again.

The reactions taking place in the vitriol chambers are very complicated, and have been explained in many different ways. The view now accepted by most chemists is that developed by Lunge, according to which there are two principal reactions succeeding each other, it may be in quite contiguous places, but under different conditions. Where the nitrous fumes prevail and there is less water present, sulphur dioxide combines with nitrous acid and oxygen to form nitroso-sulphuric acid, a crystalline substance of the formula $SO_2(OH)(ONO)$. The reaction is therefore:—$SO_2 + O + NO_2H = SO_5NH$. The solid substance is, however, only exceptionally met with, as it at once dissolves in the mist of sulphuric acid floating in the chamber, and forms "nitrous vitriol." Wherever this nitrous vitriol comes into contact with liquid water (*not* steam), which is also present in the chamber in the shape of mist, and practically as dilute sulphuric acid, it is decomposed into sulphuric and nitrous acid, thus:—$SO_2(OH)(ONO) + H_2O = H_2SO_4 + NO_2H$. The re-formed nitrous acid, although not stable, any more than is its anhydride, N_2O_3, is nevertheless the "oxygen carrier" in question, as the products of its spontaneous decomposition, when meeting with other compounds, always react like nitrous acid itself and thus may transfer an indefinite quantity of oxygen to the corresponding quantities of SO_2 and H_2O, with the corresponding formation of H_2SO_4. This theory at once explains, among other things, why the acid formed in the vitriol chambers always contains an excess of water (the second of the above-quoted reactions requiring the "mass action" of this excess), and why the external cooling produced by the contact of the chamber sides with the air is of great importance (*liquid* water in the shape of a mist of dilute sulphuric acid being necessary for the process).

The commercial production of sulphuric acid imperatively requires that the nitrogen oxides (which originally were always introduced in the shape of nitric acid) should be available as long as possible, before being lost mechanically or by reduction to the inactive forms of nitrous oxide or elementary nitrogen. The first step towards securing this requirement was taken as early as 1827 by Gay-Lussac, who discovered that the nitrous fumes, otherwise carried away from the lead chambers by the waste atmospheric nitrogen and oxygen, could be retained by bringing the gases into contact with moderately strong sulphuric acid, the result being the formation of nitroso-sulphuric acid: $2H_2SO_4 + N_2O_3 = 2SO_2(OH)(ONO) + H_2O$, and the latter remaining dissolved in sulphuric acid as "nitrous vitriol." But this important invention was of little use until John Glover, about 1866, found that the nitrous vitriol could be most easily reintroduced into the process by subjecting it to the action of burner-gas, before this enters into the lead chambers, preferably after diluting it with chamber acid, that is, acid of from 65 to 70 per cent., H_2SO_4, as formed in the lead chambers. The reaction is then: $2SO_2(OH)(ONO) + SO_2 + 2H_2O = 3H_2SO_4 + 2NO$; that is to say, all the "nitre" is returned to the chambers in the shape of NO; the sulphuric acid employed in the Gay-Lussac process is not merely recovered, but an additional quantity is formed from fresh SO_2; as the heat of the burner-gases also comes into play, much water is evaporated which supplies part of the steam required for the working of the chambers; and the acid issues from the apparatus in a "denitrated" and sufficiently concentrated state (78 to 80 per cent. H_2SO_4) to be used over again for absorbing nitrous vapours or any other purpose desired. Since that time, in every properly appointed sulphuric acid manufactory, the following cycle of operations is carried out. To begin with, in the burners pyrites (or, as the case may be, brimstone or blende) is made to yield hot burner-gas, containing about 7 per cent. (in the case of brimstone 10 or 11 per cent.) of SO_2. This, after having been deprived of most of the flue-dust, is passed through the "Glover tower," *i.e.*, an upright cylindrical or square tower, consisting of a leaden shell lined with heat- and acid-proof stone or brick, and loosely filled or "packed" with the same material, over which a mixture of acid from the Gay-Lussac tower and from the chambers trickles down in such proportions that it arrives at the bottom as denitrated acid of from 78 to 80 per cent. The gases then pass on to the "chambers," structures of lead, generally about 20 feet wide, 18 feet high, and 100 or 150 feet long. Several such chambers are usually combined to a "set," with a cubic capacity of as much as 150,000 cubic feet or even more. Here the gases meet with more nitrous vapours, and with steam, or with water, converted into a fine dust or spray. Here the reactions sketched above take place, so that "chamber-acid" as already described is formed, while a mixture of gases escapes containing all the atmospheric nitrogen, some oxygen in excess, about 0·5 per cent. of the total SO_2, and some oxides of nitrogen. This gas is now passed through the Gay-Lussac tower, which somewhat resembles the Glover tower, but is usually filled with coke, over which sulphuric acid of about 80 per cent., H_2SO_4, trickles down in sufficient quantity to retain the nitrous vapours. Ultimately the waste gas is drawn off by a chimney, or sometimes by mechanical means.

Of course a great many special improvements have been made in the plant and the working of chamber systems; of these we mention only some of the most important. By judiciously watching all stages of the process, by observing the draught, the strength of the acid produced, the temperature, and especially by frequent analyses of the gases, the yield of acid has been brought up to 98 per cent. of the theoretical maximum, with a loss of nitre sometimes as low as two parts to 100 of sulphur burned. The supply of the nitric acid required to make up this loss is obtained in England by "potting," that is, by decomposing solid nitrate of soda by sulphuric acid in a flue between the pyrites burners and the chambers. On the Continent makers generally prefer to employ liquid nitric acid, which is run through the Glover tower together with the nitrous vitriol. Although this method appears more troublesome, it allows the amount of nitre to be more easily and more accurately regulated. The size of the Glover towers, and more especially that of the Gay-Lussac towers, has been progressively increased, and thereby the cube of the lead chambers themselves has been diminished to a much greater extent. By improved "packing," the towers have been rendered more durable, and in the case of the Gay-Lussac tower, the loss of nitre has been diminished by avoiding the use of a coke packing, which acts upon that substance as a reducing agent. Many attempts have been made to reduce the chamber space by apparatus intended to bring about a better mixture of the gases, and to facilitate the interaction of the misty particles of nitrous vitriol and dilute acid floating in the chamber with each other, and with the chamber atmosphere. The earliest really successful, and still the most generally applied apparatus of this kind, is the Lunge-Rohrmann "plate columns" or "reaction towers" placed between the chambers, but though this and similar apparatus has proved to be very useful in the later stages of the process, it has not been found practicable to do away with the lead chambers entirely. The pumping of the acids up to the top of the towers is now always performed by means of compressed air, either in the old "acid eggs," or more economically in "pulsometers."

Most of the sulphuric acid manufactured is not required to be of higher strength than is furnished by the vitriol chambers, either directly (65 to 70 per cent.), or after a passage through the Glover tower (78 to 80 per cent.) This, for instance, holds good of the acid employed in the manufacture of sulphate of soda and hydrochloric acid from common salt, and in the manufacture of superphosphates. But for many purposes more highly concentrated acid is required. Until quite recently all such acid was made by boiling down the dilute acid, for which purpose a great variety of apparatus has been invented. The first question is always that of material. Lead can be used for the purpose only when the boiling-point of the acid is reduced by means of a vacuum—a plan which has not met with much success. Formerly glass vessels were generally employed and they still survive in England, but elsewhere they are not much used. Porcelain, enamelled iron, for high concentrations even cast-iron without any protection, are also in use. On the Continent platinum vessels have been for a long time almost universal, and they have been recently greatly improved by an internal lining of gold. The second consideration is the form of the vessels; these may be open pans or dishes, or closed retorts, or combinations of both. We also note the Faure and Kessler apparatus, which consists of a platinum pan, surmounted by a double-walled leaden hood, in such a manner that, while the hood is constantly cooled from the outside by water, the thin acid condensing on its inside is carried away without being allowed to flow back into the pan. The majority of acid makers, however, prefer retorts made entirely of platinum, preferably provided by the Heraeus process with a dense, closely adherent coating of gold, including the top or "dome." The new Kessler furnace is a very ingenious apparatus, in which the fire from a gas-producer travels over the sulphuric acid contained in a trough made of Volvic lava, and surmounted by a number of perforated plates, over which fresh acid is constantly running down; the temperature is kept down by the production of a partial vacuum, which greatly promotes the volatilization of the water, whilst retarding that of the acid. This furnace is also very well adapted for impure acids, unsuitable for platinum or platinum-gold stills on account of the crusts forming at the bottom of the retorts; and it is more and more coming into use both in Great Britain and on the Continent. A third consideration is the condensation of the vapours formed in the concentrating process; the further the concentration proceeds the more sulphuric acid they contain. Condensation is a comparatively easy task in the case of platinum apparatus, but with glass or porcelain beakers or retorts it presents great difficulties. In this respect the Kessler furnace has also proved to be very efficacious. The highest strength practically attainable by boiling down is 98 per cent. H_2SO_4, and this is only exceptionally reached, since it involves much expenditure of fuel, loss of acid, and wear and tear of apparatus. The usual strength of the O.V. of commerce, mostly designated by its specific gravity as 168° Twaddell, is from 93 to 95, or at most 96 per cent. H_2SO_4. When attempts are made to push the process beyond 98 per cent., it is found that the acid which distils over is as strong as that which remains behind. Real "monohydrate" or acid approaching 100 per cent. can be made by Lunge's process of cooling strong O.V. down to − 16° C. when H_2SO_4 crystallizes out, or by the addition of anhydrous SO_3 in the shape of fuming acid.

Fuming or Nordhausen oil of vitriol, a mixture or chemical compound of H_2SO_4 with more or less SO_3, has been made for centuries by exposing pyritic schist to the influence of atmospheric agents, collecting the solution of ferrous and ferric sulphate thus formed, boiling it down into a hard mass ("vitriolstein") and heating this to a low red heat in small earthenware retorts. Since about 1800 this industry had been confined to the north-west of Bohemia, and it survived just till 1900, when it was entirely abandoned—not because its product had become any less necessary, but, quite on the contrary, because the enormously increasing demand for fuming sulphuric acid, arising through the discovery of artificial alizarine and other coal-tar colours, could not possibly be supplied by the clumsy Bohemian process. Other sources of supply had accordingly to be sought, and they were found by going back to a reaction known since the first quarter of the 19th century, when Doebereiner discovered the combination of SO_2 and O into SO_3 by means of spongy platinum. This reaction, now known by the name of the catalytic or contact process, was made the subject of a patent by Philips, in 1831, and was tried later in many ways, but had been always considered as useless for practical purposes until 1875, when it was simultaneously and independently taken up by Clemens Winkler in Freiberg, and by Squire and Messel in London. Both these inventors began in the same way, viz., by decomposing ordinary sulphuric acid by a high temperature into SO_2, O, and H_2O (the last of course being in the shape of steam), absorbing the water by sulphuric acid, and causing the SO_2 and O to combine to SO_3 by means of moderately heated platinum in a fine state of division. Winkler showed that this division was best obtained by soaking asbestos with a solution of platinum chloride and reducing the platinum to the metallic state, and he described later a specially active kind of "contact substance," prepared from platinum chloride at a low temperature. This revival of the synthetical production of SO_3, at a period when this article had suddenly become of great importance, caused the greatest excitement among chemists and led to numerous attempts in the same direction, some of which were at once sufficiently successful to compete with the Bohemian process. It was soon found that the production of a mixture of SO_2 and O from sulphuric acid, as above described, was both too troublesome and costly, and after a number of experiments in other directions inventors went back to the use of ordinary burner-gas from pyrites and sulphur burners. For a good many years the further development of this industry was surrounded by great mystery, but it is now known that a satisfactory solution of the difficulties existing in the above respect was attained in several places, for instance, at Freiberg and in London, by the labours of the original inventors, Professor Winkler and Dr Messel. These difficulties were mostly caused by the solid impurities contained in the burner-gases in the shape of flue-dust, especially the arsenic, which after a short time rendered the contact substance inactive, in a manner not as yet entirely understood. Another difficulty arose from the fact that the reaction $SO_2 + O = SO_3$ is reversible, the opposite reaction, $SO_3 = SO_2 + O$ setting in but little above the temperature required for the synthesis of SO_3. As far as is known (so much secrecy having been observed) the best results obtained in various places, save one, did not exceed 67 per cent. of the theoretical quantity, the remaining 33 per cent. of SO_2 having to be converted into sulphuric acid in the ordinary lead chambers. As is now known, the exception (undoubtedly the only one until 1899) was the process discovered as early as 1889 by Dr Knietsch, of the Badische Anilin-und-Soda-Fabrik, at Ludwigshafen, but kept strictly secret until 1899, when the patents were published. The principal features of this invention are, first, a much more thorough purification of the burner-gas than had been practised up to that time, both in a chemical and a mechanical sense, and second, the prevention of superheating of the contact substance, which formerly always occurred by the heat generated in the process itself. As the Badische process effects this prevention by cooling the contact apparatus by means of the gaseous mixture to be later submitted to the catalytic action, the mixture is at the time heated up to the requisite temperature, and a considerable saving of fuel is the consequence. Altogether this process has been brought to such a pitch of simplicity and perfection, that it is cheap enough, not merely for the manufacture of fuming oil of vitriol of all strengths, but even for that of ordinary sulphuric acid of chamber-acid strength, while it is decidedly cheaper than the old process in the case of stronger acids, otherwise obtained by concentration by fire. It should be noted that these are not the results of a few years' working with an experimental plant, but of many years' work with large plant, now equal to a capacity of 120,000 tons of pyrites per annum. It is therefore not too much to say that, in all probability, the contact process will ultimately be employed generally for concentrated acids. Still, for the reasons given in the beginning of this article, the revolution thus impending will require a certain time for its accomplishment. Since the Badische process has become known, several other new contact processes have come into the field, in some of which ferric oxide is employed as contact substance, but we must refrain from describing these in detail.

Hydrochloric Acid and Sulphate of Soda.—As long as the Leblanc process was paramount in alkali manufacture, the decomposition of sodium chloride (common salt) by sulphuric acid was in the first instance carried on for the purpose of obtaining sulphate of soda, commercially known as "salt-cake." Hydrochloric acid (muriatic acid) was a necessary by-product of the reaction: $2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$, but in some cases it was altogether treated as a waste-product, which at the same time constituted a great nuisance. Generally it was more or less perfectly recovered, but only exceptionally was it utilized to the fullest possible extent. The technical progress of the manufacture of hydrochloric acid (comp. *Ency. Brit.* vol. v. p. 678, and vol. xxii. p. 243) was promoted, to an extent perhaps unique in the history of legislative efforts, by the passing of the Alkali Acts, in 1863, 1874, 1881, and 1892, owing to the exemplary way in which the duties as inspector under these Acts were carried out by the late Dr R. Angus Smith and his successors, who directed their efforts not merely to their primary duty of preventing nuisance, but quite as much to showing manufacturers how to make the most of the acid formerly wasted in one shape or another. Not merely Great Britain but all mankind has been immensely benefited by the labours of the British alkali inspectors, which were of course supplemented by the work of technical men in all the countries concerned. The scientific and technical principles of the condensation of hydrochloric acid are now thoroughly well understood, and it is possible to recover nearly the whole of it in the state of strong commercial acid, containing from 32 to 36 per cent. of HCl, although probably the majority of the manufacturers are still content to obtain part of the acid in a much weaker state, merely to satisfy the requirements of the law prescribing the prevention of nuisance. The principles of the condensation, that is of converting the gaseous HCl given off during the decomposition of common salt into a strong solution of hydrogen chloride in water, can be summarized in a few words. The vapours of HCl, which are always diluted with air, sometimes to a very great extent, must be brought into the most intimate contact possible with water, which greedily absorbs the gas, forming ordinary hydrochloric acid, and this process must be carried so far that scarcely any HCl remains in the escaping gases. The maximum escape allowed by the Alkali Acts, viz., 5 per cent. of the total HCl, is far above that which is now practically attained. For a proper utilization of this condensed acid it is nearly always imperative that it should be as strong as possible, and this forms a second important consideration in the construction of the condensing apparatus. Since the solubility of HCl in water decreases with the increase of the temperature, it is necessary to keep the latter down—a task which is rendered somewhat difficult both by the original heat retained by the gases on their escape from the decomposing apparatus and by the heat given off through the reaction of HCl upon water.

Very different methods have been employed to effect all the above purposes. In Great Britain Gay-Lussac's coke towers, adapted by Gossage to the condensation of hydrochloric acid, are still nearly everywhere in use, frequently combined with a number of stone tanks through which the gas from the furnaces travels before entering the towers, meeting on its way the acid condensed in the tower. This process is excellent for effecting a complete condensation of the HCl as prescribed by the Alkali Acts, and for recovering the bulk of the acid in a tolerably strong state, but less so for recovering nearly the whole of it in the most concentrated state, although even this is occasionally attained. On the Continent, where the last-named requirement has been for a long time more urgent than in Great Britain, another system has been generally preferred, namely, passing the gas through a long series of stoneware receivers, and ultimately through a small tower packed with stoneware or coke, making the acid flow in the opposite direction to the gas. Great success has also been obtained by specially-constructed "plate towers" (already mentioned in connexion with their application to the manufacture of sulphuric acid), which allow both the coke towers and most of the stoneware receivers to be dispensed with.

Improvements in the construction of the condensing apparatus had to go hand in hand with those in the construction of the "salt-cake furnaces" for treating the common salt with sulphuric acid. The ordinary way of effecting this treatment is to carry out the first reaction in cast-iron pans or "pots," fired from below, and to complete it by applying a higher temperature in a "roasting-furnace." If the latter is constructed as a reverberatory furnace, where the HCl given off is mixed with the products of the combustion of the fuel, the acid obtained during this part of the operation is necessarily weak. It is therefore altogether preferable to construct the roasting-furnace as a "muffle," heated only on the outside, although the expenditure of more fuel is thus involved. The drawback formerly caused by leakages of acid gases into the fire-flues through cracks in the muffle has been removed by the construction of "plus-pressure furnaces." Many and often very costly attempts have been made to construct mechanical salt-cake furnaces. Of these Mactear's furnaces have met with the greatest success, though this is limited by the fact that, apart from their great cost, they yield the hydrochloric acid in a weaker state than hand-wrought furnaces. For this reason they have been abandoned in some places, and are not likely to be generally introduced. The same holds good of the "direct salt-cake process" of Hargreaves and Robinson, in which salt is subjected to the action of burner-gases and steam at a low red heat, thus effecting the reaction:

$2NaCl + SO_2 + O + H_2O = Na_2SO_4 + 2HCl$, without the intervention of lead chambers. This process, which requires complicated and costly plant, has been most ingeniously elaborated by the inventors, and has been made a perfect success for the manufacture of very pure sulphate of soda, also for the complete condensation of the HCl, but the latter is less easily obtained in the strong state possible with muffle furnaces, owing to the dilution of the gas with nitrogen, &c. (comp. *Ency. Brit.* vol. xxii. p. 242).

The manufacture of sodium sulphate and hydrochloric acid has been put on an entirely different economical basis through several great changes in the alkali industry, which have checked the further expansion of the Leblanc process. This process, which formerly absorbed most of the salt-cake produced, is giving place more and more to the ammonia-soda process, which starts directly from sodium chloride. Outside Great Britain the Leblanc process now plays a very subordinate part, and in Great Britain itself it will certainly not spread any farther and will probably ultimately succumb, although this may be in a somewhat remote future. The only other considerable outlet for salt-cake is the manufacture of glass, which naturally cannot be indefinitely extended. These circumstances, by restricting both the quantity and still more the value of the sodium sulphate, necessarily conferred a greater value upon the hydrochloric acid manufactured along with it; and as this acid was until recently indispensable for the production of chlorine, the enhanced price of bleaching-powder and chlorate of potash for a time compensated the manufacturer for his loss on the salt-cake, and thus again reacted favourably on the economical aspect of the Leblanc process. Much more attention is now devoted than formerly to the preparation of the hydrochloric acid in a strong state, and to processes intended to make it yield a greater amount of chlorine. The recent development of the electrolysis of the alkaline chlorides necessarily again decreases the value of the hydrochloric acid obtained in the manufacture of salt-cake, and must in the end lead to a further restriction in the production of the latter.

The Manufacture of Alkali.—The term "alkali" is usually applied to several sodium compounds, viz., the hydrate (caustic soda), the carbonate (soda-ash), and the bicarbonate. The corresponding potassium compounds are almost exclusively made in Germany, from Stassfurt salts, and in France, from the "vinasse" of beet-root manufactures. The alkali manufacture in this sense is intimately connected with the chlorine industry, and both have for a long time formed the most important of British chemical industries. In vol. xxii. p. 242 a description has been given of the two principal forms of the soda manufacture, viz., the Leblanc process and the ammonia-soda process. The *Leblanc process* was for a long time that by which nearly all alkali was made. During the last decade many improvements have been effected in all its stages, principally by the development of mechanical furnaces and by attention to details; in this connexion Dr Hurter's name should be especially mentioned. Its greatest drawback, viz., the loss of the sulphur originally introduced into the process, and formerly only imperfectly and at not sufficiently small cost recovered from the "tank-waste" by the processes of Mond and Schaffner, has been overcome by the Claus-Chance sulphur recovery process. This consists in decomposing the calcium sulphide of the tank-waste, which had been previously reduced to a thin watery paste, by means of impure carbonic acid in the shape of lime-kiln gas, and converting the resulting H_2S either into sulphuric acid, or, preferably, into a very pure form of free sulphur. Thus 85 per cent. of the sulphur is recovered in a much more valuable form than it originally possessed in the shape of pyrites, and the remaining 15 per cent. as well as the solid residue of the operation are at least rendered innocuous.

In spite of these great improvements the Leblanc process cannot economically compete with the *ammonia-soda process*, principally for two reasons. The sodium in the latter costs next to nothing, being obtained from natural or artificial brine in which the NaCl possesses an extremely slight value. The fuel required is less than half the amount used in the Leblanc process. Moreover, the process has been gradually elaborated into a very complicated and costly, but perfectly regularly working scheme, in which the cost of labour and the loss of ammonia are reduced to a minimum. The only way in which the Leblanc process could still hold its own was by being turned in the direction of making caustic soda, to which it lends itself more easily than the ammonia-soda process; but the latter has recently invaded even this field. One advantage, however, still remained to the Leblanc process. All endeavours to obtain either hydrochloric acid or free chlorine in the ammonia-soda process turned out economical failures, all the chlorine of the sodium chloride being ultimately lost in the shape of worthless calcium chloride. The Leblanc process thus remained the sole purveyor of chlorine in its active shapes, and in this way the fact is accounted for that, at least in Great Britain, the Leblanc process still furnishes nearly half of all the alkali made, while in other countries its proportional share is very much less. The profit made upon the chlorine produced has to make up for the loss on the alkali.

But the position still held by the Leblanc process is seriously threatened by the development of the *electrolytic decomposition of the alkaline chlorides*, which has taken place principally since 1890. These processes possess some of the advantages of both the old processes. They start with the cheapest form of NaCl, viz., brine; and they at once furnish the most valuable form of alkali, viz., caustic soda, and at the same time either free chlorine, or, directly, bleaching-liquor of chlorates. Up to a certain stage they require no fuel, except for the production of energy, which may be furnished by the cheapest kind of motors,—best of all, by water-power. Only for the conversion of the strong solution of alkali obtained in the electrolytic cell into a solid form is some fuel indispensable. The great difficulties at first experienced with electrodes and diaphragms do not seem to exist any more; and so far as the production of *chlorine compounds* is concerned, there seems to be nothing to stop the triumph of electrolysis over the old processes, which were described in vol. v. p. 678. We must not omit to notice that the electrolysis of sodium chloride and the manufacture of alkali in a commercial shape are decidedly more difficult than the corresponding operations in the case of potassium chloride. But to the inroads of electrolysis into the domain of alkali manufacture, there is one natural limitation brought about by the fact that this process produces for each 40 parts of NaOH, equivalent to 53 parts of Na_2CO_3, 35·5 parts of chlorine, which yield about 100 parts of bleaching-powder, whereas the present consumption of chlorine products is in the proportion of about one part of bleaching-powder (or its equivalent of chlorates) to five parts of alkali. Manifestly only that quantity of alkali can be made which corresponds to the sale of the chlorine products necessarily made at the same time, and this means that about nine-tenths of the alkali consumed must be made in other ways. As far as we can see, the ammonia-soda process will supply the principal portion of the great remainder, but for some time the Leblanc process will still contribute a share, and "natural soda" from California, from Egypt, &c. (comp. vol. xxii. p. 240) will come in to a certain extent.

Nitric acid (comp. vol. xvii. p. 518).—The manufacture of this acid has been very largely extended, on account both of the enormously increased production of explosives for engineering and mining purposes and of the substitution of smokeless powders for the old gunpowder made from saltpetre. But it is still effected by the wasteful process of decomposing sodium nitrate by sulphuric acid, producing as residue "nitre-cake," a product of very little value. Several attempts have been made to decompose the nitrate in a more profitable way, *e.g.*, by means of ferric oxide, in which case the soda is converted into the valuable shape of NaOH, and the ferric oxide is recovered as such; but none of these processes have emerged beyond the experimental stage. The old process has been improved on various sides, chiefly by the elaboration of more rational systems of condensation, and by conducting the operation in such a manner that it furnishes at once a maximum of strong and sufficiently pure acid, which does not need to be freed from the lower oxides of nitrogen by the process of "bleaching"; also by separating the decomposition of sodium nitrate into two stages and conducting it as a continuous process, with the employment of comparatively weak sulphuric acid even for the production of strong nitric acid (the Rhenania-Uebel process).

REFERENCES.—The principal work on acids and alkali is Lunge's *Sulphuric Acid and Alkali*, 2nd ed. 3 vols. 1891-96. The same work has also appeared in French (by Lunge and Naville), 3 vols. 1879-81, and in German, 2nd ed. 3 vols. 1893-96. The same author has given a synopsis of the manufacture of sulphuric acid up to 1899 in his article "Schwefel" in Muspratt's *Chemie*, 4th ed. vii. 1114-1368. Other works are:—JURISCH, *Handbuch der Schwefelsäurefabrikation*, 1893.—SOREL, *Fabrication de l'acide sulfurique*, 1887.—*Annual Reports on Alkali, &c., Works*, from 1864 upwards.—*Journal of the Society of Chemical Industry*, from 1882. FISCHER's *Jahresberichte der chemischen Technologie*. *Chemische Industrie*. *Zeitschrift für angewandte Chemie*.

(G. L.)

Acireale, a town and episcopal see of the province of Catania, Sicily, Italy, 9 miles N. by E. from Catania by rail. It has a school of the industrial arts and sciences. Population, 25,900 (1881); 35,459 (1901).

Acland, Sir Henry Wentworth Dyke, BART. (1815-1900), British medical professor and man of learning, was born 23rd August 1815, and was the fourth son of Sir Thomas Dyke Acland. He was educated at Harrow and Christ Church, was elected Fellow of All Souls' in 1841, and, following the medical profession, took his Oxford degree of M.D. in 1848, having in 1845 been appointed Lee's Reader in Anatomy. The revival of medical study and the introduction of the study of natural science into Oxford were in great measure due to Sir Henry Acland. He promoted in every way the foundation of laboratories and of the Oxford Museum, formed an extensive series of physiological preparations on the plan of John Hunter, and did far more to overcome the indifference and remove the suspicion generally prevalent when he commenced his labours than could have been achieved by one less generally acceptable from his birth, his amenity, and the elevation of his character. "To Henry Acland," says Ruskin, "physiology was an intrusted gospel of which he was the solitary preacher to the heathen." On the other hand, as has been well observed, his thorough classical training preserved science at Oxford from too abrupt a severance from the humanities. In conjunction with his intimate friend, Dean Liddell, he revolutionized the study of art and archæology, so that the cultivation of these subjects, for which, as Ruskin declared, no one at Oxford cared before their time, began to flourish in the University. He published a memoir on the visitation of cholera in 1854, and another on the topography of the Troad; but his claims to remembrance rest chiefly on his systematic, sedulous, and successful promotion of his favourite objects. He was Radcliffe librarian (1851), Regius Professor of Medicine (1858), and president of the General Medical Council from 1874 to 1887; he was also a curator of the University Galleries and of the Bodleian library. He was created a baronet in 1890. He resigned the Regius Professorship in 1894, and died in October 1900.

Acoustics.—The original article in the ninth edition of this *Encyclopædia* (hereafter referred to as O. A.) contains an account of many of the leading phenomena of acoustics and their elementary theory, so that it is only necessary here to supplement that account by discussing certain theoretical points, and by describing certain phenomena and methods of investigation which have been brought into more prominent notice, or have been discovered, in recent years.

Velocity of sound.

The following elementary method of obtaining the velocity of plane waves of longitudinal disturbance in air brings into prominence the fact that the velocity depends on and varies slightly with the excess and defect of pressure from the normal or undisturbed value. The method with appropriate modification will give the velocity of transverse disturbance in strings and longitudinal disturbance in rods. We suppose that a disturbance, the same at every point in a plane perpendicular to the direction of propagation, is in some way made and started in the air, and that external forces are applied to every particle in such a manner that the disturbance is constrained to move on with uniform velocity unchanged in form. The force per unit mass can be expressed in terms of the pressures due to the state of strain together with the applied force, and it can also be expressed in terms of the acceleration which is obtained from the condition that the disturbance moves on unchanged in form with constant velocity U. For this implies that the change in velocity of a particle at a given point during a small time dt is equal to the difference in the velocities at a given instant at that point, and at a point a distance Udt back along the line of propagation.

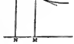


Fig. 1.

In Fig. 1 let QP represent the displacement curve of the disturbance (O. A. § 12). Let NM represent two points distant Udt apart along the line of propagation. Let MP, NQ, represent at a given instant the displacements of the particles which were originally at rest at M, N, but which are now displaced in the direction of propagation by amounts proportional to MP and NQ. Let u_M, u_N represent the velocities of the particles. Then the velocity of the M particle will change from u_M to u_N in time dt, so that the acceleration a is given by

$$a = \frac{u_N - u_M}{dt} = U\frac{u_N - u_M}{NM} \quad . \quad . \quad (1)$$

since $NM = Udt$.

But, drawing the tangent PT at P, the velocity at P is the rate at which the displacement is growing at P as the displacement curve travels along, and this is evidently at the rate TS per time taken by the disturbance to travel over NM.

Then $$u_M = \frac{TS}{dt} = U.\frac{TS}{NM} \quad . \quad . \quad . \quad (2)$$

This may be written as $-U\frac{dy}{dx}$. But we may express the pressure excess at M in terms of the displacement. For if the layer of air originally between M and N were all compressed as it is at P, the surface through N would be displaced forward NT, while that through M would only be displaced forward MP, or there would be a compression TS in length MN. Since the disturbance is purely longitudinal, this implies that there is a diminution of volume proportional to TS in volume proportional to MN, or if v is the decrease of volume per original volume V,

$$\frac{v}{\mathrm{V}}=\frac{\mathrm{TS}}{\mathrm{MN}}.$$

But if E is the elasticity of the air, and if p_{M} is the excess of pressure producing the decrease of volume, by definition we have

$$p_{\mathrm{M}}=\mathrm{E}\frac{v}{\mathrm{V}}=\mathrm{E}.\frac{\mathrm{TS}}{\mathrm{MN}}$$

from (2)
$$=\frac{\mathrm{E}}{\mathrm{U}}.u_{\mathrm{M}} \qquad . \quad . \quad . \quad . \qquad (3)$$

This relation shows that wherever the particle velocity is forward p_{M} is in excess, and that wherever it is backward p_{M} is in defect of the undisturbed or normal pressure.

We may evidently put $p_{\mathrm{M}}=-\mathrm{E}.\frac{dy}{dx}$.

Forming a similar expression for p_{N} and subtracting

$$p_{\mathrm{N}}-p_{\mathrm{M}}=\frac{\mathrm{E}}{\mathrm{U}}(u_{\mathrm{N}}-u_{\mathrm{M}}),$$

and substituting in (1)

$$a=\frac{\mathrm{U}^2}{\mathrm{E}}\frac{p_{\mathrm{N}}-p_{\mathrm{M}}}{\mathrm{NM}} \qquad . \quad . \qquad (4)$$

Turning now to the forces acting on the layer originally between M and N and 1 sq. cm. in cross section, we have $\mathrm{P}+p_{\mathrm{N}}$ at N and $\mathrm{P}+p_{\mathrm{M}}$ at M, where P is the normal pressure. There is also the applied force. If this is X per mass 1, and if the normal density is ρ, then the total force on mass ρMN is

$$p_{\mathrm{N}}-p_{\mathrm{M}}+\mathrm{X}\rho\mathrm{MN},$$

and the acceleration is

$$a=\frac{p_{\mathrm{N}}-p_{\mathrm{M}}}{\rho\mathrm{NM}}+\mathrm{X} \qquad . \qquad (5)$$

Equating (4) and (5) we obtain

$$\mathrm{U}^2=\frac{\mathrm{E}}{\rho}\left(1+\frac{\rho.\mathrm{NM}.\mathrm{X}}{p_{\mathrm{N}}-p_{\mathrm{M}}}\right) \qquad . \quad . \quad . \qquad (6)$$

If the disturbance is so small that the change in volume may be taken as exactly proportional to the change in pressure, then E is constant. If then X=0, or there is no external applied force,

$$\mathrm{U}^2=\mathrm{E}/\rho$$

(the value found in O. A. § 15). But if the disturbance is great we can no longer assume that E is the same for all changes of volume. We may, however, suppose that the change of pressure consists of two terms: (1) a term exactly proportional to the change in volume; (2) a term, in general very small, expressing the divergence from proportionality. If we like, we may regard the second term as an applied force superposed on the force expressed in the first term, and then trace the effect in equation (6). The relation between pressure and volume in air for sound disturbance is the adiabatic relation

$$\mathrm{PV}^{\gamma}=\text{constant},$$

where γ=ratio of specific heats. If P change to $\mathrm{P}+p$ and V to $\mathrm{V}-v$,

$$(\mathrm{P}+p)(\mathrm{V}-v)^{\gamma}=\mathrm{PV}^{\gamma},$$

or
$$1+\frac{p}{\mathrm{P}}=\left(1-\frac{v}{\mathrm{V}}\right)^{-\gamma}.$$

Expanding the right hand and neglecting powers above the second,

$$\frac{p}{\mathrm{P}}=\gamma\frac{v}{\mathrm{V}}+\gamma\frac{(\gamma+1)}{2}\frac{v^2}{\mathrm{V}^2}.$$

If the second term on the right did not exist, we should have

$$p=\gamma\mathrm{P}\frac{v}{\mathrm{V}},$$

and the elasticity would have the constant value

$$\mathrm{E}=\gamma\mathrm{P}.$$

We assume now that the elasticity does have this value, and that the second term is an applied force superposed on the pressures deduced from a constant elasticity which were used in obtaining equation (6). In that equation we must take the applied force on element cross section 1^2, length NM, as

ρ.NM.X = excess of pressure denoted by second term at N,
 " " " " " at M.

$$=\gamma\frac{\gamma+1}{2}\mathrm{P}.\left\{\left(\frac{v}{\mathrm{V}}\right)_{\mathrm{N}}^2-\left(\frac{v}{\mathrm{V}}\right)_{\mathrm{M}}^2\right\}.$$

Now in the denominator of the fraction in (6), $p_{\mathrm{N}}-p_{\mathrm{M}}$ represents pressures deduced from a constant elasticity, so that,

$$p_{\mathrm{N}}-p_{\mathrm{M}}=\mathrm{E}\left\{\left(\frac{v}{\mathrm{V}}\right)_{\mathrm{N}}-\left(\frac{v}{\mathrm{V}}\right)_{\mathrm{M}}\right\}.$$

Substituting these values in (6)

$$\mathrm{U}^2=\frac{\mathrm{E}}{\rho}\left[1+\gamma\frac{\gamma(\gamma+1)}{2\mathrm{E}}\mathrm{P}\left\{\left(\frac{v}{\mathrm{V}}\right)_{\mathrm{N}}+\left(\frac{v}{\mathrm{V}}\right)_{\mathrm{M}}\right\}\right]$$

$$=\frac{\mathrm{E}}{\rho}\left\{1+(\gamma+1)\frac{v}{\mathrm{V}}\right\}$$

$\left(\text{since } \mathrm{E}=\gamma\mathrm{P} \text{ and } \left(\frac{v}{\mathrm{V}}\right)_{\mathrm{N}} \text{ is in the limit equal to } \left(\frac{v}{\mathrm{V}}\right)_{\mathrm{M}}\right)$

$$=\frac{\mathrm{E}}{\rho}\left(1+\frac{\gamma+1}{\gamma}\frac{p}{\mathrm{P}}\right)$$

$$=\frac{\mathrm{E}}{\rho}\left(1+(\gamma+1)\frac{u}{\mathrm{U}}\right) \qquad \text{from (3)}$$

or
$$\mathrm{U}=\sqrt{\frac{\mathrm{E}}{\rho}}\left(1+\frac{\gamma+1}{2}\frac{u}{\mathrm{U}}\right)$$

$$=\sqrt{\frac{\mathrm{E}}{\rho}}+\frac{\gamma+1}{2}u \qquad . \quad . \quad . \qquad (7)$$

This result implies that the different parts of a wave move on at different rates, so that its form must change. As we obtained the result on the supposition of unchanged form, we can of course only apply it for such short lengths and such short times that the part dealt with does not appreciably alter. We see at once that, where $u=0$, the velocity has its "normal" value, while where u is positive the velocity is in excess, and where u is negative the velocity is in defect of the normal value. If, then, a (Fig. 2) represent the displacement curve of a train of waves, b will represent the pressure excess and particle velocity, and from (7) we see that while the nodal conditions of b, with $p=0$ and $u=0$, travel with velocity $\sqrt{\frac{\mathrm{E}}{\rho}}$, the crests exceed that velocity by $\frac{\gamma+1}{2}u$, and the hollows fall short of it by $\frac{\gamma+1}{2}u$, with the result that the fronts of the pressure waves become steeper and steeper, and the train b changes into something like c. If the steepness get very great our investigation ceases to apply, and neither experiment nor theory has yet shown what happens. Probably there is a breakdown of the wave somewhat like the breaking of a water-wave when the crest gains on the next trough. In ordinary sound-waves the effect of the particle velocity in affecting the velocity of transmission must be very small.

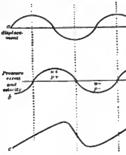


Fig 2.

Experiments, referred to later, have been made to find the amplitude of swing of the air particles in organ pipes. Thus Mach found an amplitude 0·2 cm. when the issuing waves were 250 cm. long. The amplitude in the pipe was probably much greater than in the issuing waves. Let us take it as 0·1 mm. in the waves—a very extreme value. The maximum particle velocity is $2\pi na$ (where n is the frequency and a the amplitude), or $2\pi a\mathrm{U}/\lambda$. This gives maximum u = about 80 cm/sec., which would not seriously change the form of the wave in a few wave lengths. Meanwhile the waves are spreading out and the value of u is falling in inverse proportion to the distance from the source, so that very soon its effect must become negligible.

But in loud sudden sounds, such as a peal of thunder or the report of a gun, the effect may be more considerable, and there is no doubt that with such sounds the normal velocity is quite considerably exceeded. Thus there is the old observation of Parry (§ 23, O. A.) that from a distance the report of a gun was heard before the word "Fire." More recently Jaques (*Phil. Mag.* 1879, vii. p. 219) has investigated the transmission of the report from a cannon in different directions, finding that it rose to a maximum of 1267 $^{\text{ft}}/_{\text{sec}}$ at 70 to 90 feet in the rear, and then fell off. If, too, the sound be confined in pipes so that the intensity cannot diminish rapidly the normal velocity is exceeded. Thus Regnault in his classical experiments (*Phil. Mag.* 1868, xxxv. p. 161) found that the velocity of the report of a pistol carried through a pipe diminished with the intensity, and his results have been confirmed by Violle and Vautier (*Phil. Mag.* 1888, xxvi. p. 77). Possibly the prolonged boom into which the report of a gun changes at a distance is due to some kind of break-down and lengthening out of the original disturbance when the front of the pressure wave becomes impossibly steep.

Reflection.

Some light has been thrown on the curious "whispering gallery" case of reflection of sound by observations made by Lord Rayleigh in the circular gallery at the base of the dome of St. Paul's Cathedral. An old explanation of the effect consisted in ascribing it to the concentration of the sound rays after single reflection from the surface to a focus conjugate to the source, or to the crowding in a caustic (O. A. § 38). But Lord Rayleigh finds that "the abnormal loudness with which a whisper is heard is not confined to the position diametrically opposite to that occupied by the whisperer, and therefore, it would appear, does not depend materially upon the symmetry of the dome. The whisper seems to creep round the gallery horizontally, not necessarily along the shorter arc, but rather along that arc towards which the whisperer faces. This is a consequence of the very unequal audibility of a whisper in front and behind the speaker, a phenomenon which may easily be observed in the open air" (*Sound*, ii. § 287).

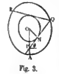


Fig. 3.

Let Fig. 3 represent a horizontal section of the dome through the source P. Let OPA be the radius through P. Let PQ represent a ray of sound making θ with the tangent at A. Let $ON = OP \cos \theta$ be the perpendicular on PQ. Then the reflected ray QR and the ray reflected at R, and so on, will all touch the circle drawn with ON as radius. A ray making less than θ with the tangent will with its reflections touch a larger circle. Hence all rays between $\pm\theta$ will be confined in the space between the outer dome and a circle of radius $OP \cos \theta$, and the weakening of intensity will be chiefly due to vertical spreading.

Rayleigh points out that this clinging of the sound to the surface of a concave wall does not depend on the exactness of the spherical form. He suggests that the propagation of earthquake disturbances is probably affected by the curvature of the surface of the globe, which may act like a whispering gallery.

In some cases of echo, when the original sound is a compound musical note, the octave of the fundamental tone is reflected much more strongly than that tone itself. This is explained by Rayleigh (*Sound*, ii. § 296) as a consequence of the irregularities of the reflecting surface. The irregularities send back a scattered reflection of the different incident trains, and this scattered reflection becomes more copious the shorter the wave length. Hence the octave, though comparatively feeble in the incident train, may predominate in the scattered reflection constituting the echo.

Temperature refraction.

Osborne Reynolds (*Proc. R. S.* xxii. 1874, p. 531) first pointed out that refraction would result from a variation in the temperature of the air at different heights. The velocity of sound in air is independent of the pressure, but varies with the temperature, its value at $t°$ C. being (O. A. § 18)—

$$U = U_0\left(1 + \frac{at}{2}\right),$$

where U_0 is the velocity at 0° C., and a is the coefficient of expansion ·00365. Now if the temperature is higher overhead than at the surface, the velocity overhead is greater. If a wave front is in a given position, as *a* 1, (Fig. 4), at a given instant, the upper part moving faster gains on the lower, and the front tends to swing round as shown by the successive positions in *a* 2, 3, and 4; that is, the sound tends to come down to the surface. This is well illustrated by the remarkable horizontal carriage of sound on a still clear frosty morning, when the surface layers of air are decidedly colder than those above. At sunset, too, after a warm day, if the air is still, the cooling of the earth by radiation cools the lower layers, and sound carries excellently over a level surface. But usually the lower layers are warmer than the upper layers, and the velocity below is greater than the velocity above. Consequently a wave front such as *b* 1 tends to turn upwards, as shown in the successive positions *b* 2, 3, and 4. Sound is then not so well heard along the level, but may still reach an elevated observer. On a hot summer's day the temperature of the surface layers may be much higher than that of the higher layers, and the effect on the horizontal carriage of sound may be very marked.

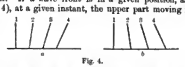


Fig. 4.

Refraction by wind.

It is well known that sound travels far better with the wind than against it. Stokes showed that this effect is one of refraction, due to variation of velocity of the air from the surface upwards (*B. A. Rep.* 1857, p. 22). It is, of course, a matter of common observation that the wind increases in velocity from the surface upwards. An excellent illustration of this increase was pointed out by Osler in the shape of old clouds; their upper portions always appear dragged forward and they lean over, as it were, in the direction in which the wind is going. The same kind of thing happens with sound-wave fronts when travelling with the wind.

The velocity of any part of a wave front relative to the ground will be the normal velocity of sound + the velocity of the wind at that point. Since the velocity increases as we go upwards, the front tends to swing round and travel downwards, as shown in the successive positions *a* 1, 2, 3, and 4, in Fig. 4, when we must suppose the wind to be blowing from left to right. But if the wind is against the sound the velocity of a point of the wave front is the normal velocity − the wind velocity at the point, and so decreases as we rise. Then the front tends to swing round and travel upwards as shown in the successive positions *b* 1, 2, 3, and 4, in Fig. 4, where the wind is travelling from right to left. In the first case the waves are more likely to reach and be perceived by an observer level with the source, while in the second case they may go over his head and not be heard at all.

Many of the well-known phenomena of optical diffraction may be imitated with sound-waves, especially if the waves be short. Lord Rayleigh has given various examples, and accounts of experiments and theory will be found in his *Sound*, vol. ii.

Frequency and pitch.

A simple mode of forming Lissajous figures, to find the ratio of the frequencies of two forks, consists in attaching two small plane mirrors, one on the prong of one fork, the other on a prong of another fork. The two forks are arranged so that one vibrates in a vertical, the other in a horizontal plane, and they are so placed that a converging beam of light, received in one mirror, is reflected to the other and then brought to a point on a screen. If the first fork alone vibrates, the point on the screen appears lengthened out into a vertical line through the changes in inclination of the first mirror, while if the second fork alone vibrates, the point appears lengthened out into a horizontal line. If both vibrate, the point describes a curve which appears continuous through the persistence of the retinal impression. The curve is named a Lissajous figure after the deviser of this method of investigation. Lissajous also obtained the figures by aid of the vibration microscope, an instrument which he invented. Instead of a mirror, the objective of a microscope is attached to one prong of the first fork and the eye-piece of the microscope is fixed behind the fork. Instead of a mirror the second fork carries a bright point on one prong, and the microscope is focussed on this. If both forks vibrate, an observer looking through the microscope sees the bright point describing Lissajous figures. If the two forks have the same frequency, it is easily seen that the figure will be an ellipse (including as limiting cases, depending on relative amplitude and phase, a circle and a straight line). If the forks are not of exactly the same frequency the ellipse will slowly revolve, and from its rate of revolution the ratio of the frequencies may be determined (Rayleigh, *Sound*, i. § 33). If one is the octave of the other a figure of 8 may be described, and so on.

Koenig's tuning-fork clock.

Koenig has devised a clock in which a fork of frequency 64 takes the place of the pendulum (*Wied. Ann.* ix. p. 394, 1880). The motion of the fork is maintained by the clock acting through an escapement, and the dial registers both the number of vibrations of the fork and the seconds, minutes, and hours. By comparison with a clock of known rate the total number of vibrations of the fork in any time may be accurately determined. One prong of the fork carries a microscope objective, part of a vibration microscope, of which the eye-piece is fixed at the back of the clock, and the Lissajous figure made by the clock fork and any other fork may be observed. With this apparatus Koenig studied the effect of temperature on a standard fork of 256 frequency, and found that the frequency decreased by ·0286 of a vibration for a rise of 1°, the frequency being exactly 256 at 26·2° C. Hence the frequency may be put as $256\,\{1-\cdot000113\,(t-26\cdot2)\}$.

Koenig also used the apparatus to investigate the effect on the frequency of a fork of a resonating cavity placed near it. He found that when the pitch of the cavity was below that of the fork the pitch of the fork was raised, and *vice versâ*. But when the pitch of the cavity was exactly that of the fork when vibrating alone, though it resounded most strongly, it did not affect the frequency of the fork. These effects have been explained by Lord Rayleigh (*Sound*, i. § 117).

M'Leod and Clarke's stroboscopic method.

In the stroboscopic method of M'Leod and Clarke, the full details of which will be found in the original memoir (*Phil. Trans.* 1880, part i, p. 1), a cylinder is ruled with equidistant white lines parallel to the axis on a black ground. It is set so that it can be turned at any desired and determined speed about a horizontal axis, and when going fast enough it appears grey. Imagine now that a fork with black prongs is held near the cylinder with its prongs vertical and the plane of vibration parallel to the axis, and suppose that we watch the outer outline of the right-hand prong. Let the cylinder be rotated so that each white line moves exactly into the place of the next while the prong moves once in and out. Hence when a white line is in a particular position on the cylinder, the prong will always be the same distance along it and cut off the same length from view. The most will be cut off in the position of the lines corresponding to the furthest swing out, then less and less till the furthest swing in, then more and more till the furthest swing out, when the appearance will be exactly as at first. The boundary between the grey cylinder and the black fork will therefore appear wavy with fixed undulations, the distance from crest to crest being the distance between the lines on the cylinder. If the fork has slightly greater frequency, then a white line will not quite reach the next place while the fork is making its swing in and out, and the waves will travel against the motion of the cylinder. If the fork has slightly less frequency the waves will travel in the opposite direction, and it is easily seen that the frequency of the fork is the number of white lines passing a point in a second ± the number of waves passing the point per second. This apparatus was used to find the temperature coefficient of the frequency of forks, the value obtained −·00011 being the same as that found by Koenig. Another important result of the investigation was that the phase of vibration of the fork was not altered by bowing it, the amplitude alone changing. The method is easily adapted for the converse determination of speed of revolution when the frequency of a fork is known.

Rayleigh's phonic wheel.

The phonic wheel, invented independently by La Cour and Lord Rayleigh (see *Sound*, i. § 68 *c*), consists of a wheel carrying several soft iron armatures fixed at equal distances round its circumference. The wheel rotates between the poles of an electro-magnet, which is fed by an intermittent current such as that which is working an electrically maintained tuning-fork (see *infra*). If the wheel be driven at such rate that the armatures move one place on in about the period of the current, then on putting on the current the electro-magnet controls the rate of the wheel so that the agreement of period is exact, and the wheel settles down to move so that the electric driving forces just supply the work taken out of the wheel. If the wheel has very little work to do it may not be necessary to apply driving power, and uniform rotation may be maintained by the electro-magnet. In an experiment described by Rayleigh such a wheel provided with four armatures was used to determine the exact frequency of a driving fork known to have a frequency near 32. Thus the wheel made about 8 revolutions per second. There was one opening in its disc, and through this was viewed the pendulum of a clock beating seconds. On the pendulum was fixed an illuminated silver bead which appeared as a bright point of light when seen for an instant. Suppose now an observer to be looking from a fixed point at the bead through the hole in the phonic wheel, he will see the bead as 8 bright points flashing out in each beat, and in succession at intervals of $\frac{1}{8}$ second. Let us suppose that he notes the positions of two of these next to each other in the beat of the pendulum one way. If the fork makes exactly 32 vibrations and the wheel 8 revolutions in one pendulum beat, then the positions will be fixed, and every two seconds, the time of a complete pendulum vibration, he will see the two positions looked at flash out in succession at an interval of $\frac{1}{8}$ second. But if the fork has, say, rather greater frequency, the hole in the wheel comes round at the end of the two seconds before the bead has quite come into position, and the two flashes appear gradually to move back in the opposite way to the pendulum. Suppose that in N beats of the clock the flashes have moved exactly one place back. Then the first flash in the new position is viewed by the 8Nth passage of the opening, and the second flash in the original position of the first is viewed when the pendulum has made exactly N beats and by the $(8\,N+1)$th passage of the hole. Then the wheel makes 8 N + 1 revolutions in N clock beats, and the fork makes 32 N + 4 vibrations in the same time. If the clock is going exactly right, this gives a frequency for the fork of $32+\frac{4}{N}$. If the fork has rather less frequency than 32 then the flashes appear to move forward and the frequency will be $32-\frac{4}{N}$. In Rayleigh's experiment the 32 fork was made to drive electrically one of frequency about 128, and somewhat as with the phonic wheel, the frequency was controlled so as to be exactly 4 times that of the 32 fork. A standard 128 fork could then be compared either optically or by beats with the electrically driven 128, and the frequency of the standard determined.

Doppler's principle.

A very noticeable illustration of the alteration of pitch by motion occurs when a whistling locomotive moves rapidly past an observer. As it passes, the pitch of the whistle falls quite appreciably. The explanation is simple. The engine follows up any wave that it has sent forward, and so crowds up the succeeding waves into a less distance than if it remained at rest. It draws off from any wave it has sent backward and so spreads the succeeding waves over a longer distance than if it had remained at rest. Hence the forward waves are shorter and the backward waves are longer. Since $U=n\lambda$ where U is the velocity of sound, λ the wave length, and n the frequency, it follows that the forward frequency is greater than the backward frequency.

The more general case of motion of source, medium, and receiver, may be treated very easily if the motions are all in the line joining source and receiver. Let S (Fig. 5) be the source at a given instant, and let its frequency of vibration, or the number of waves it sends out per second, be n. Let S' be its position, one second later, its velocity being u. Let R be the receiver at a given instant, R' its position a second later, its velocity being v. Let the velocity of the air from S to R be w, and let U be the velocity of sound in still air. If all were still, the n waves emitted by S in one second would spread over a length U. But through the wind velocity the first wave is carried to a distance $U+w$ from S, while through the motion of the source the last wave is a distance u from S. Then the n waves occupy a space $U+w-u$. Now turning to the receiver, let us consider what length is occupied by the waves which pass him in one second. If he were at rest, it would be the waves in length $U+w$, for the wave passing him at the beginning of a second would be so far distant at the end of the second. But through his motion v in the second, he receives only the waves in distance $U+w-v$. Since there are n waves in distance $U+w-u$ the number he actually receives is

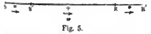


Fig. 5.

$$n\frac{U+w-v}{U+w-u}.$$

If the velocities of source and receiver are equal then the frequency is not affected by their motion or by the wind. But if their velocities are different, the frequency of the waves received is affected both by these velocities and by that of the wind.

The change in pitch through motion of the source may be illustrated by putting a pitch-pipe in one end of a few feet of rubber tubing and blowing through the other end, while the tubing is whirled round the head. An observer in the plane of the motion can easily hear a change in the pitch as the pitch-pipe moves to and from him.

Quality.

A musical note has a definite pitch or frequency, that is, it is a disturbance of definite periodicity. Yet notes of the same pitch, emitted by different instruments, have quite different timbre or quality. The three characteristics of a longitudinal periodic disturbance are its amplitude, the length after which it repeats itself, and its form which may be represented by the shape of the displacement curve. Now the amplitude evidently corresponds to the loudness, and the length of period corresponds to the pitch or frequency. Hence we must put down the quality or timbre as depending on the form.

The simplest form of wave, so far as our sensation goes, that is, the one giving rise to a pure tone, is, we have every reason to suppose, one in which the displacement is represented by a harmonic curve or a curve of sines,

$$y=a\sin m(x-e).$$

If we put this in the form

$$y=a\sin\frac{2\pi}{\lambda}(x-e),$$

we see that $y=0$, for $x=e$, $e+\frac{\lambda}{2}$, $e+\frac{2\lambda}{2}$, $e+\frac{3\lambda}{2}$, and so on, that y is + from $x=e$ to $x=e+\frac{\lambda}{2}$, − from $e+\frac{\lambda}{2}$ to $e+\frac{2\lambda}{2}$, and so on, and that it alternates between the values $+a$ and $-a$.

The form of the curve is evidently as represented in Fig. 6, and it may easily be drawn to exact scale from a table of sines.

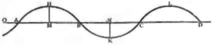


Fig. 6.

In this curve ABCD are nodes. OA = e is termed the epoch, being the distance from O of the first ascending node. AC is the shortest distance after which the curve begins to repeat itself; this length λ is termed the wave length. The maximum height of the curve HM = a is the amplitude. If we transfer O to A, $e=0$, and the curve may be represented by

$$y=a\sin\frac{2\pi}{\lambda}x.$$

If now the curve moves along unchanged in form in the direction ABC with uniform velocity U, the epoch e = OA at any time t will be Ut, so that the value of y may be represented as

$$y=a\sin\frac{2\pi}{\lambda}(x-Ut) \quad . \quad . \quad . \quad (1)$$

The velocity perpendicular to the axis of any point on the curve at a fixed distance x from O is

$$\frac{dy}{dt}=-\frac{2\pi Ua}{\lambda}\cos\frac{2\pi}{\lambda}(x-Ut) \quad . \quad . \quad (2)$$

The acceleration perpendicular to the axis is

$$\frac{d^2y}{dt^2}=-\frac{4\pi^2U^2a}{\lambda^2}\sin\frac{2\pi}{\lambda}(x-Ut)$$
$$=-\frac{4\pi^2U^2}{\lambda^2}y.$$

which is an equation characteristic of simple harmonic motion.

The chief experimental basis for supposing that a train of longitudinal waves with displacement curve of this kind arouses the sensation of a pure tone, is that the more nearly a source is made to vibrate with a single simple harmonic motion, and therefore, presumably, the more nearly it sends out such a harmonic train, the more nearly does the note heard approximate to a single pure tone.

The average energy per cc. of a harmonic train of waves may easily be calculated. If ρ is the density, the kinetic energy in a length λ parallel to ABC, of cross section 1 sq. cm., is

$$\frac{1}{2}\int_0^\lambda \rho\left(\frac{dy}{dt}\right)^2 dx$$
$$\frac{\rho}{2}\int_0^\lambda \frac{4\pi^2U^2a^2}{\lambda^2}\cos^2\frac{2\pi}{\lambda}(x-Ut)dx \quad . \quad \text{from (2)}$$
$$=\frac{\rho\pi^2U^2a^2}{\lambda}.$$

The potential energy in volume cross section 1 length dx, manifested by the strain, may be calculated since it is equal to average pressure × strain produced,

or
$$\left(P+\frac{p}{2}\right)v\,dx,$$

where p is the pressure excess and v the volume change per unit volume.

Now from equation (3) in the investigation of the velocity of sound (*supra*), we see that

$$p = -\mathrm{E}\frac{dy}{dx},$$

while putting V = 1

$$v = -\frac{dy}{dx}.$$

Inserting these values and integrating the potential energy between $x=0$ and $x=\lambda$, we have

$$-\int_0^\lambda\left(\mathrm{P}-\frac{\mathrm{E}}{2}\frac{dy}{dx}\right)\frac{dy}{dx}dx \quad = -\mathrm{P}\int_0^\lambda\frac{dy}{dx}dx+\frac{\mathrm{E}}{2}\int_0^\lambda\left(\frac{dy}{dx}\right)^2dx.$$

But differentiating (1) above

$$\frac{dy}{dx}=\frac{2\pi a}{\lambda}\cos\frac{2\pi}{\lambda}(x-\mathrm{U}t),$$

and as this has equal + and − values over a length $x=\lambda$, the first integral = 0. The second gives on integration

$$\frac{\pi^2\mathrm{E}a^2}{\lambda}.$$

Then, since $\mathrm{E}=\rho\mathrm{U}^2$, the potential energy in one wave length, cross section 1,

$$=\frac{\rho\pi^2\mathrm{U}^2a^2}{\lambda}.$$

The total energy, kinetic + potential, in a length λ of cross section 1 is equally divided between the two kinds, and is

$$\frac{2\rho\pi^2\mathrm{U}^2a^2}{\lambda}.$$

If we regard this energy as travelling on with velocity U, the quantity passing across one sq. cm. in one second is U/λ times as great, or

$$\frac{2\rho\pi^2\mathrm{U}^3a^2}{\lambda^2}.$$

This gives the measure of the intensity of the sound on the supposition that loudness or intensity is to be measured by energy received per sq. cm. per second. From the values of the particle velocity and the pressure excess, it is easy to express the intensity in terms of these quantities.

Any periodic curve may be resolved into sine or harmonic curves by Fourier's theorem.

Fourier's theorem.

Suppose that any periodic sound disturbance, consisting of plane waves, is being propagated in the direction ABCD, Fig. 7. Let it be represented by a displacement curve AHBKC. Its periodicity implies that after a certain distance the displacement curve exactly repeats itself. Let AC be the shortest distance after which the repetition occurs, so that CLDME is merely AHBKC moved on a distance AC. Then AC = λ is the wave length or period of the curve. Let ABCD be drawn at such level that the areas above and below it are equal; then ABCD is the axis of the curve. Since the curve represents a longitudinal disturbance in air it is always continuous, at a finite distance from the axis, and with only one ordinate for each abscissa.

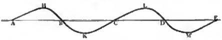


Fig 7.

Fourier's theorem asserts that such a curve may be built up by the superposition, or addition of ordinates, of a series of sine curves of wave lengths $\lambda, \frac{\lambda}{2}, \frac{\lambda}{3}, \frac{\lambda}{4}$ . . . if the amplitudes a, b, c . . . and the epochs e, f, g . . . are suitably adjusted, and the proof of the theorem gives rules for finding these quantities when the original curve is known. We may therefore put

$$y=a\sin\frac{2\pi}{\lambda}(x-e)+b\sin\frac{4\pi}{\lambda}(x-f)+c\sin\frac{6\pi}{\lambda}(x-g)+\text{etc.} \qquad (1)$$

where the terms may be infinite in number, but always have wave lengths submultiples of the original or fundamental wave length λ. Only one such resolution of a given periodic curve is possible, and each of the constituents repeats itself not only in its own wave length λ/*n*, but also evidently in the fundamental wave length λ. The successive terms of (1) are called the *harmonics of the first term.*

It follows from this that any periodic disturbance in air can be resolved into a definite series of simple harmonic disturbances of wave lengths equal to the original wave length and its successive submultiples, and each of these would separately give the sensation of a pure tone. If the series were complete, we should have terms which separately would correspond to the fundamental, its octave, its twelfth, its double octave, and so on. Now we can see that two notes of the same pitch, but of different quality, or different form of displacement curve, will, when thus analysed, break up into series having the same harmonic wave lengths; but they may differ as regards the members of the series present and their amplitudes and epochs. We may regard quality, then, as determined by the members of the harmonic series present and their amplitudes and epochs. It may, however, be stated here that certain experiments of Helmholtz appear to show that the epoch of the harmonics has not much effect on the quality.

Fourier's theorem can also be usefully applied to the disturbance of a source of sound under certain conditions. The nature of these conditions will be best realized by considering the case of a stretched string. It is shown, in O. A. § 55, how the vibrations of a string may be deduced from stationary waves. Let us here suppose that the string AB is displaced into the form AHB (Fig. 8). Then let us imagine it to form half a wave length of the extended train ZGAHBKC, on an indefinitely extended stretched string, the values of y at equal distances from A (or from B) being equal and opposite. Then we may suppose the vibrations of the string to be represented by the travelling of two trains in opposite directions each with velocity

$$\sqrt{\text{tension} \div \text{mass per unit length}}$$

each half the height of the train represented in Fig. 8. For the superposition of these trains will give a stationary wave between A and B. Now we may resolve these trains by Fourier's theorem into harmonics of wave lengths $\lambda, \frac{\lambda}{2}, \frac{\lambda}{3}$, etc., where $\lambda = 2\mathrm{AB}$ and the condition as to the values of y can be shown to require that the harmonics shall all have nodes, coinciding with the nodes of the fundamental curve. Since the velocity is the same for all disturbances they all travel at the same speed, and the two trains will always remain of the same form. If then we resolve AHBKC into harmonics by Fourier's theorem, we may follow the motion of the separate harmonics, and their superposition will give the form of the string at any instant. Further, the same harmonics with the same amplitude will always be present.

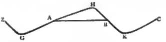


Fig. 8.

We see, then, that the conditions for the application of Fourier's theorem are equivalent to saying that all disturbances will travel along the system with the same velocity. In many vibrating systems this does not hold, and then Fourier's theorem is no longer an appropriate resolution. But where it is appropriate, the disturbance sent out into the air contains the same harmonic series as the source.

The question now arises whether the sensation produced by a periodic disturbance can be analysed in correspondence with this geometrical analysis. Using the term note for the sound produced by a periodic disturbance, there is no doubt that a well-trained ear can resolve a note into pure tones of frequencies equal to those of the fundamental and its harmonics. If, for instance, a note is struck and held down on a piano, a little practice enables us to hear both the octave and the twelfth with the fundamental, especially if we have previously directed our attention to these tones by sounding them. But the harmonics are most readily heard if we fortify the ear by an air cavity with a natural period equal to that of the harmonic to be sought. The form used by Helmholtz is a globe of thin brass with a large hole at one end of a diameter, at the other end of which the brass is drawn out into a short, narrow tube that can be put close to the ear. But a card-board tube closed at one end, with the open end near the ear, will often suffice, and it may be tuned by more or less covering up the open end. If the harmonic corresponding to the resonator is present its tone swells out loudly.

Resonators.

This resonance is a particular example of the general principle that a vibrating system will be set in vibration by any periodic force applied to it, and ultimately in the period of the force, its own natural vibrations gradually dying down. Vibrations thus excited are termed *Forced Vibrations*, and their amplitude is greater the more nearly the period of the applied force approaches that of the system when vibrating freely. The mathematical investigation of forced vibrations (Rayleigh, *Sound*, i. § 46) shows that, if there were no dissipation of energy, the vibration would increase indefinitely when the periods coincided. But there is always leakage of energy either through friction or through wave-emission, so that the vibration only increases up to the point at which the leakage of energy balances the energy put in by the applied force. Further, the greater the dissipation of energy the less is the prominence of the amplitude of vibration for exact coincidence over the amplitude when the periods are not quite the same, though it is still the greatest for coincidence.

The ear as a Fourier analyser.

According to Helmholtz, the ear probably contains within it a series of resonators, with small intervals between the periods of the successive members, while the series extends over the whole range of audible pitch. We need not here enter into the question of the structure constituting these resonators. Each of them is supposed to have its own natural frequency, and to be set into vibration when the ear receives a train of waves of that frequency. The vibration in some way arouses the sensation of the corresponding tone. But the same resonator will be appreciably though less affected by waves of frequency differing slightly from its own. Thus Helmholtz from certain observations (Rayleigh, *Sound*, ii. § 388) thought that if the intensity of response by a given resonator in the ear to its own tone is taken as 1, then its response to an equally loud tone a semitone different may be taken as about $\frac{1}{10}$. According to this theory, then, when a pure tone is received the auditory apparatus corresponding to that tone is most excited, but the apparatus on each side of it is also excited, though by a rapidly diminishing amount, as the interval increases. If the sensations corresponding to these neighbouring elements are thus aroused, we have no such perception as a pure tone, and what we regard as a pure tone is the mean of a group of sensations. The sensitiveness of the ear in judging of a given tone must then correspond to the accuracy with which it can judge of the mean.

Amplitude of vibration.

Determinations of the pressure changes, or extent of excursion of the air, in sounding organ pipes have been made by Kundt (*Pogg. Ann.* cxxxiv. 1868, p. 163), Töpler and Boltzmann (*Pogg. Ann.* cxli., or Rayleigh, *Sound*, § 422*a*), and Mach (*Optisch-Akustischen Versuche*). Mach's method is perhaps the most direct. The pipe was fixed in a horizontal position, and along the top wall ran a platinum wire wetted with sulphuric acid. When the wire was heated by an electric current a fine line of vapour descended from each drop. The pipe was closed at the centre by a membrane which prevented a through draught, yet permitted the vibrations, as it was at a node. The vapour line, therefore, merely vibrated to and fro when the pipe was sounded. The extent of vibration at different parts of the pipe was studied through a glass side wall, a stroboscopic method being used to get the position of the vapour line at a definite part of the vibration. Mach found an excursion of 0·4 cm. at the end of an open pipe 125 cm. long. The amplitude found by the other observers was of the same order.

Minimum amplitude of audible sounds.

Lord Rayleigh has made experiments by two different methods to determine the amplitude of vibration in waves only just audible (*Sound*, ii. § 384). It will be sufficient to indicate the second method. A fork of frequency 256 was used as the source. The energy of this fork with a given amplitude of vibration could be calculated from its dimensions and elasticity, and the amplitude was observed by measuring with a microscope the line into which the image of a starch grain on the prong was drawn by the vibration. The rate of loss of energy was calculated from the rate of dying down of the vibration. This rate of loss for each amplitude was determined (1), when the fork was vibrating alone, and (2) when a resonator was placed with its mouth under the free ends of the fork. The difference in loss in the two cases measured the energy given up to and sent out by the resonator as sound. The amplitude of the fork was observed when the sound just ceased to be audible at 27·4 metres away, and the rate of energy emission from the resonator was calculated to be 42·1 $^{\text{ergs}}/_{\text{second}}$. Assuming this energy to be propagated in hemispherical waves, it is easy to find the quantity per second going through 1 sq. cm. at the distance of the listener, and thence from the energy in a wave, found above, to determine the amplitude. The result was an amplitude of $1{\cdot}27 \times 10^{-7}$ cm. Other forks gave results not very different. M. Wien (*Wied. Ann.* xxxvi. 1889, p. 834) by another method has obtained a smaller value still, though one of the same order. He used a globular resonator in which the pressure variations could be determined by a contrivance something like a delicate aneroid barometer. From the pressure changes the amplitude was known, and from Helmholtz's theory of the resonator the amplitude in the external exciting waves was calculated. All the results show that "the streams of energy required to influence the eye and ear are of the same order of magnitude."

Vibrations of air in pipes.

The simple theory of the vibration of air in pipes, due to Bernouilli, practically assumes that a stationary wave is formed with a node at a closed end and a loop at an open end. But (as pointed out in O. A. § 85) the condition for a loop at an open end, that of no pressure variation, cannot be exactly fulfilled. This would require that the air outside should have no mass in order that it should at once move out and relieve the air at the end of the pipe from any excess of pressure, or at once move in and fill up any defect. There are variations, therefore, at the open end, and these are such that the loop may be regarded as situated a short distance outside the end of the pipe. It may be noted that in practice there is another reason for pressure variation at the end of the pipe. The stationary wave method regards the vibration in the pipe as due to a series of waves travelling to the end and being there reflected back down the pipe. But the reflection is not complete, for some of the energy comes out as waves; hence the direct and reflected trains are not quite equal, and cannot neutralize each other at the loop.

The position of the loop has not yet been calculated for an ordinary open pipe, but Lord Rayleigh has shown (*Sound*, ii. § 307), that for a cylindrical tube of radius R, provided with a flat extended flange, the loop may be regarded as about

0·82 R, in advance of the end. That is, the length of the pipe must be increased by 0·82 R before applying Bernouilli's theory. This is termed the end correction. Using this result Rayleigh found the correction for an unflanged open end by sounding two pipes nearly in unison, each provided with a flange, and counting the beats. Then the flange was removed from one and the beats were again counted. The change in virtual length by removal of the flange was thus found, and the open end correction for the unflanged pipe was 0·6 R. This correction has also been found by Blaikley by direct experiment (*Phil. Mag.* vii. 1879, p. 339). He used a tube of variable length and determined the length resounding to a given fork, (1) when the closed end was the first node, (2) when it was the second node. If these lengths are l_1 and l_2, then $l_2 - l_1 = \frac{\lambda}{2}$ and $\frac{l_2 - l_1}{2} - l_1$ is the correction for the open end. The mean value found was 0·576 R.

Propagation of waves in pipes.

Helmholtz investigated the velocity of propagation of sound in pipes, taking into account the viscosity of the air (Rayleigh, *Sound*, ii. § 347), and Kirchhoff investigated it, taking into account both the viscosity and the heat communication between the air and the walls of the pipe (*Sound*, ii. § 350). Both obtained the value for the velocity

$$U\left(1 - \frac{C}{R\sqrt{2\pi N\rho}}\right),$$

where U is the velocity in free air, R is the radius of the pipe, N the frequency, and ρ the air density. C is a constant, equal to the coefficient of viscosity in Helmholtz's theory, but less simple in Kirchhoff's theory. Experiments on the velocity in pipes were carried out by Schneebeli (*Pogg. Ann.* cxxxvi. 1869, p. 296), and by Seebeck (*Pogg. Ann.* cxxxix. 1870, p. 104) which accorded with this result as far as R is concerned, but the diminution of velocity was found to be more nearly proportional to $N^{-\frac{3}{4}}$. Kundt also obtained results in general agreement with the formula (Rayleigh, *Sound*, ii. § 260). He used his dust-tube method (O. A. § 93).

Specific heats' ratio.

Kundt's dust-tube may also be employed for the determination of the ratio of the specific heats of a gas or vapour. If U is the velocity of sound in a gas at pressure P with density ρ, and if waves of length λ and frequency N are propagated through it, then the distance between the dust-heaps is

$$d = \frac{\lambda}{2} = \frac{U}{2N} = \frac{1}{2N}\sqrt{\frac{\gamma P}{\rho}},$$

where γ is the ratio of the two specific heats. If d is measured for two gases in succession for the same frequency N, we have

$$\frac{\gamma_2}{\gamma_1} = \frac{\rho_2 P_1}{\rho_1 P_2}\frac{d_2^2}{d_1^2},$$

where the suffixes denote the gases to which the quantities relate. If γ_1 is known this gives γ_2. Kundt and Warburg applied the method to find γ for mercury vapour (*Pogg. Ann.* clvii. 1876, p. 356), using a double form of the apparatus in which there are two dust-tubes worked by the same sounding rod. This rod is supported at $\frac{1}{4}$ and $\frac{3}{4}$ of its length where it enters the two dust tubes, as represented diagrammatically in Fig. 9. It is stroked in the middle so as to excite its second mode of vibration. The method ensures that the two frequencies shall be exactly the same. In the mercury experiment the sounding rod was sealed into the dust-tube, which was exhausted of air, and contained only some mercury and some quartz dust to give the heaps. It was placed in a high temperature oven, where the mercury was evaporated. The second tube containing air was outside. When a known temperature was attained the sounder was excited, and d_2 and d_1 could be measured. From the temperature, P_2/ρ_2 was known, and γ_2/γ_1 could then be found. Taking $\gamma_1 = 1·41$, γ_2 was determined to be 1·66. Rayleigh and Ramsay (*Phil. Trans.* A. 1895, part i. p. 187) also used a single dust-tube with a sounder to find γ for argon, and again the value was 1·66.

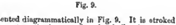


Fig. 9.

Maintenance of vibrations.

When a system is set vibrating and left to itself, the vibration gradually dies away as the energy leaks out either in the waves formed or through friction. In order that the vibration may be maintained, a periodic force must be applied either to aid the internal restoring force on the return journey, or weaken it on the outgoing journey, or both. Thus if a pendulum always receives a slight impulse in the direction of motion just about the lowest point, this is equivalent to an increase of the restoring force if received before passage through the lowest point, and to a decrease if received after that passage, and in either case it tends to maintain the swing. If the bob of the pendulum is iron, and if a coil is placed just below the centre of swing, then, if a current passes through the coil, while and only while the bob is moving towards it, the vibration is maintained. If the current is on while the bob is receding, the vibration is checked. If it is always on it only acts as if the value of gravity were increased, and does not help to maintain or check the vibration, but merely to shorten the period.

Electrically maintained fork.

In a common form of electrically maintained fork, the fork is set horizontal with its prongs in a vertical plane, and a small electro-magnet is fixed between them. The circuit of the electro-magnet is made and broken by the vibration of the fork in different ways—say, by a wire bridge attached to the lower prong which dips into and lifts out of two mercury cups. The mercury level is so adjusted that the circuit is just not made when the fork is at rest. When it is set vibrating contact lasts during some part of the outward and some part of the inward swing. But partly owing to the delay in making contact through the carriage down of air on the contact piece, and partly owing to the delay in establishing full current through self-induction, the attracting force does not rise at once to its full value in the outgoing journey, whereas in the return journey the mercury tends to follow up the contact piece, and the full current continues up to the instant of break. Hence the attracting force does more work in the return journey than is done against it in the outgoing, and the balance is available to increase the vibration.

Organ pipe.

In the organ pipe—as in the common whistle—a thin sheet of air is forced through a narrow slit at the bottom of the embouchure and impinges against the top edge, which is made very sharp. The disturbance made at the commencement of the blowing will no doubt set the air in the pipe vibrating in its own natural period, just as any irregular air disturbance will set a suspended body swinging in its natural period, but we are to consider how the vibration is maintained when once set going. When the motion due to the vibration is up along the pipe from the embouchure, the air moves into the pipe from the outside, and carries the sheet-like stream in with it to the inside of the sharp edge. This stream does work on the air, aiding the motion. When the motion is reversed and the air moves out of the pipe at the embouchure, the sheet is deflected on to the outer side of the sharp edge, and no work is done against it by the air in the pipe. Hence the stream of air does work during half the vibration which is not abstracted during the other half, and so goes on increasing the motion until the supply of energy in blowing is equal to the loss by friction and sound.

Singing tube.

The maintenance of the vibration of the air in the singing tube (described O. A. § 89) has been explained by Rayleigh (*Sound*, ii. § 322 *h*) as due to the way in which the heat is communicated to the vibrating air. When the air in a pipe open at both ends is vibrating in its simplest mode, the air is alternately closing into and out from the centre. During the quarter swing ending with greatest nodal pressure, the kinetic energy is changed to potential energy manifested in the increase of pressure. This becomes again kinetic in the second quarter swing, then in the third quarter it is changed to potential energy again, but now manifested in the decrease of pressure. In the last quarter it is again turned to the kinetic form. Now suppose that at the end of the first quarter swing, at the instant of greatest pressure, heat is suddenly given to the air. The pressure is further increased and the potential energy is also increased. There will be more kinetic energy formed in the return journey and the vibration tends to grow. But if the heat is given at the instant of greatest rarefaction, the increase of pressure lessens the difference from the undisturbed pressure, and lessens the potential energy, so that during the return less kinetic energy is formed and the vibration tends to die away. And what is true for the extreme points is true for the half periods of which they are the middle points; that is, heat given during the compression half aids the vibration, and during the extension half damps it. Now let us apply this to the singing tube. Let the gas jet tube be of somewhat less than half the length of the singing tube, and let the lower end of the jet tube be in a wider tube or cavity so that it may be regarded as an "open end." When the air in the singing tube is singing, it forces the gas in the jet tube to vibrate in the same period and in such phase that at the nozzle the pressure in both tubes shall be the same. The lower end of the jet tube, being open, is a loop, and the node may be regarded as in an imaginary prolongation of the jet tube above the nozzle. It is evident that the pressure condition will be fulfilled only if the motions in the two tubes are in the same direction at the same time, closing into and opening out from the nodes together. When the motion is upwards gas is emitted; when the motion is downwards it is checked. The gas enters in the half period from least to greatest pressure. But there is a slight delay in ignition, partly due to expulsion of incombustible gas drawn into the jet tube in the previous half period, so that the most copious supply of gas and heat is thrown into the quarter period just preceding greatest pressure, and the vibration is maintained. If the jet tube is somewhat longer than half the sounding tube there will be a node in it, and now the condition of equality of pressure requires opposite motions in the two at the nozzle, for their nodes are situated on opposite sides of that point. The heat communication is then chiefly in the quarter vibration just preceding greatest rarefaction, and the vibration is not maintained.

Sensitive flames and jets.

When a flame is just not flaring, any one of a certain range of notes sounded near it may make it flare while the note is sounding. This was first noticed by Leconte (*Phil. Mag.* xv. 1858, p. 235), and later by Barrett (*Phil. Mag.* xxxiii. 1867, p. 216). Barrett found that the best form of burner for ordinary gas pressure might be made of glass tubing about $\frac{1}{8}$ inch in diameter contracted to an orifice $\frac{1}{16}$ inch in diameter, the orifice being nicked by a pair of scissors into a V-shape. The flame rises up from the burner in a long thin column, but when an appropriate note is sounded it suddenly drops down and thickens. Barrett further showed by using smoke jets that the flame is not essential. Tyndall (*Sound*, Lecture VI. § 7 *et seq.*) describes a number of beautiful experiments with jets at higher pressure than ordinary, say 10 inches of water, issuing from a pinhole steatite burner. The flame may be 16 inches high, and on receiving a suitably high sound it suddenly drops down and roars. The sensitive point is at the orifice. Lord Rayleigh (*Sound*, ii. § 370), using as a source a "bird-call," a whistle of high frequency, formed a series of stationary waves by reflection at a flat surface. Placing the sensitive flame at different parts of this train, he found that it was excited, not at the nodes where the pressure varied, but at the loops where the motion was the greatest and where there was little pressure change. In his *Sound* (ii. chapter xxi.) he has given a theory of the sensitiveness. When the velocity of the jet is gradually increased there is a certain range of velocity for which the jet is unstable, so that any deviation from the straight rush-out tends to increase as the jet moves up. If then the jet is just on the point of instability, and is subjected at its base to alternations of motion, the sinuosities impressed on the jet become larger and larger as it flows out, and the flame is as it were folded on itself. Another form of sensitive jet is very easily made by putting a piece of fine wire gauze 2 or 3 inches above a pinhole burner and igniting the gas above the gauze. On adjusting the gas so that it burns in a thin column, just not roaring, it is extraordinarily sensitive to some particular range of notes, going down and roaring when a note is sounded. If a tube be placed over such a flame it makes an excellent singing tube.

Savart's liquid jets.

If a jet of water issues at an angle to the horizontal from a round pinhole orifice under a few inches pressure, it travels out as an apparently smooth cylinder for a short distance, and then breaks up into drops which travel at different rates, collide, and scatter. But if a tuning-fork of appropriate frequency be set vibrating with its stalk in contact with the holder of the pipe from which the jet issues, the jet appears to go over in one continuous thread. Intermittent illumination, however, with frequency equal to that of the fork shows at once that the jet is really broken up into drops, one for each vibration, and that these move over in a steady procession. The cylindrical form of jet is unstable if its length is more than π times its diameter, and usually the irregular disturbances it receives at the orifice go on growing, and ultimately break it up irregularly into drops which go out at different rates. But, if quite regular disturbances are impressed on the jet at intervals of time which depend on the diameter and speed of outflow (they must be somewhat more than π times its diameter apart), these disturbances go on growing and break the stream up into equal drops, which all move with the same velocity one after the other. An excellent account of these and other jets is given in Boys' *Soap Bubbles*, Lecture III.

Beats.

The formation of beats (as described in O. A. § 102) may be illustrated by considering the disturbance at any point due to two trains of waves of equal amplitude a and of nearly equal frequencies n_1 n_2. If we measure the time from an instant at which the two are in the same phase the resultant disturbance is

$$\begin{aligned} y &= a \sin 2\pi n_1 t + a \sin 2\pi n_2 t \\ &= 2a \cos \pi(n_1 - n_2)t \sin 2\pi \frac{n_1 + n_2}{2} t, \end{aligned}$$

which may be regarded as a harmonic disturbance of frequency $(n_1 + n_2)/2$ but with amplitude $2a \cos \pi(n_1 - n_2)t$ slowly varying with the time. Taking the square of the amplitude to represent the intensity or loudness of the sound which would be heard by an ear at the point, this is

$$\begin{aligned} &4a^2 \cos^2 \pi(n_1 - n_2)t \\ &= 2a^2\{1 + \cos 2\pi(n_1 - n_2)t\}, \end{aligned}$$

a value which ranges between 0 and $4a^2$ with frequency $n_1 - n_2$. The sound swells out and dies down $n_1 - n_2$ times per second, or there are $n_1 - n_2$ beats per second.

If, instead of considering one point in a succession of instants, we consider a succession of points along the line of propagation at the same instant, we evidently have waves of amplitude varying from $2a$ down to 0, and then up to $2a$ again in distance $U/(n_1 - n_2)$. If the difference of frequency of the two tones is so great that the beats are not heard separately, and if the two sounds are of sufficient loudness, then a tone is heard of the same frequency, $n_1 - n_2$, as the beats. This tone was first discovered by Sorge in 1740, and independently a few years later by Tartini, after whom it is named. It may easily be heard when a double whistle with notes of different pitch is blown strongly, or when two gongs are loudly sounded close to the hearer. It is heard, too, when two notes on the harmonium are loudly sounded. Formerly, it was generally supposed that the Tartini tone was due to the beats themselves, that the mere variation in the amplitude was equivalent, as far as the ear is concerned, to a superposition on the two original tones of a smooth sine displacement of the same periodicity as that variation. This view has still some supporters, and among its recent advocates are Koenig and Hermann. But it is very difficult to suppose that the same sensation would be aroused by a truly periodic displacement represented by a smooth curve, and a displacement in which the period is only in the amplitude of the to-and-fro motion, and which is represented by a jagged curve. No explanation is given by the supposition; it is merely a statement which can hardly be accepted unless all other explanations fail.

Combination tones.

Helmholtz has given a theory which certainly accounts for the production of a tone of the frequency of the beats, and for other tones all grouped under the name of combination tones. The only question is whether the intensity of the tones heard is accounted for by the theory. Combination tones may be produced in three ways:—(1) In the neighbourhood of the source; (2) in the receiving mechanism of the ear; (3) in the medium conveying the waves.

(1) We may illustrate the first method by taking a case discussed by Helmholtz (*Sensations of Tone*, App. xvi.) where the two sources are reeds or pipes blown from the same wind-chest. Let us suppose that with constant excess of pressure, p, in the wind-chest, the amplitude produced is proportional to the pressure, so that the two tones issuing may be represented by $pa \sin 2\pi n_1 t$ and $pb \sin 2\pi n_2 t$. Now as each source lets out the wind periodically it affects the pressure in the chest so that we cannot regard this as constant, but may take it as better represented by $p + \lambda a \sin(2\pi n_1 t + e) + \mu b \sin(2\pi n_2 t + f)$. Then the issuing disturbance will be

$$\begin{aligned}\{p + \lambda a \sin(2\pi n_1 t + e) + \mu b \sin(2\pi n_2 t + f)\}\{a \sin 2\pi n_1 t + b \sin 2\pi n_2 t\} \\ = pa \sin 2\pi n_1 t + pb \sin 2\pi n_2 t \\ + \frac{a^2\lambda}{2}\cos e - \frac{a^2\lambda}{2}\cos(4\pi n_1 t + e) \\ + \frac{b^2\mu}{2}\cos f - \frac{b^2\mu}{2}\cos(4\pi n_2 t + f) \\ + \frac{ab\lambda}{2}\cos\{2\pi(n_1 - n_2)t + e\} - \frac{a\lambda b}{2}\cos\{2\pi(n_1 + n_2)t + e\} \\ + \frac{ab\mu}{2}\cos\{2\pi(n_1 - n_2)t - f\} - \frac{ab\mu}{2}\cos\{2\pi(n_1 + n_2)t + f\} \quad (1)\end{aligned}$$

Thus, accompanying the two original pure tones there are (1) the octave of each; (2) a tone of frequency $(n_1 - n_2)$; (3) a tone of frequency $(n_1 + n_2)$. The second is termed by Helmholtz the *difference tone*, and the third the *summation tone*. The amplitudes of these tones are proportional to the products of a and b multiplied by λ or μ. These combination tones will in turn react on the pressure and produce new combination tones with the original tones, or with each other, and such tones may be termed of the second, third, etc. order. It is evident that we may have tones of frequency

$$hn_1 \qquad kn_2 \qquad hn_1 - kn_2 \qquad hn_1 + kn_2,$$

where h and k are any integers. But inasmuch as the successive orders are proportional to λ λ^2 λ^3, or μ μ^2 μ^3, and λ and μ are small, they are of rapidly decreasing importance, and it is not certain that any beyond those in equation (1) correspond to our actual sensations. The combination tones thus produced in the source should have a physical existence in the air, and the amplitudes of those represented in (1) should be of the same order. The conditions assumed in this investigation are probably nearly realized in a harmonium and in a double siren of the form used by Helmholtz (O. A. § 51), and in these cases there can be no doubt that actual objective tones are produced, for they may be detected by the aid of resonators of the frequency of the tone sought for. If the tones had no existence outside the ear then resonators would not increase their loudness. There is not much difficulty in detecting the difference tone by a resonator if it is held, say, close to the reeds of a harmonium, and Helmholtz succeeded in detecting the summation tone by the aid of a resonator. Further, Rucker and Edser, using a siren as source, have succeeded in making a fork of the appropriate pitch respond to both difference and summation tones (*Phil. Mag.* xxxix. 1895, p. 341). But there is no doubt that it is very difficult to detect the summation tone by the ear, and many workers have doubted the possibility, notwithstanding the evidence of such an observer as Helmholtz. Probably the fact noted by Mayer (*Phil. Mag.* ii. 1878, p. 500, or Rayleigh, *Sound*, § 386) that sounds of considerable intensity when heard by themselves are liable to be completely obliterated by graver sounds of sufficient force goes far to explain this, for the summation tones are of course always accompanied by such graver sounds.

(2) The second mode of production of combination tones by the mechanism of the receiver is discussed by Helmholtz (*Sensations of Tone*, App. XII.) and Rayleigh (*Sound*, § 68). It depends on the restoring force due to the displacement of the receiver not being accurately proportional to the displacement. This want of proportionality will have a periodicity, that of the impinging waves, and so will produce vibrations just as does the variation of pressure in the case last investigated. We may see how this occurs by supposing that the restoring force of the receiving mechanism is represented by

$$\lambda x + \mu x^2,$$

where x is the displacement and μx^2 is very small. Let an external force F act on the system, and for simplicity suppose its period is so great compared with that of the mechanism that we may take it as practically in equilibrium with the restoring force. Then

$$F = \lambda x + \mu x^2.$$

Now μx^2 is very small compared with λx, so that x is nearly equal to F/λ, and as an approximation,

$$F = \lambda x + \frac{\mu F^2}{\lambda^2}$$

or

$$x = \frac{F}{\lambda} - \mu\frac{F^2}{\lambda^3}.$$

Suppose now that $F = a \sin 2\pi n_1 t + b \sin 2\pi n_2 t$, the second term will evidently produce a series of combination tones of periodicities $2n_1$, $2n_2$, $n_1 - n_2$, and $n_1 + n_2$, as in the first method. There can be no doubt that the ear is an unsymmetrical vibrator, and that it makes combination tones, in some such way as is here indicated, out of two pure tones. Probably in most cases the combination tones which we hear are thus made, and possibly, too, the tones detected by Koenig, and by him named "beat-tones." He found that if two tones of frequencies p and q are sounded, and if q lies between Np and $(N+1)p$, then a tone of frequency either $(N+1)p - q$, or of frequency $q - Np$, is heard. The difficulty in Helmholtz's theory is to account for the audibility of such beat tones when they are of a higher order than the first. Rucker and Edser quite failed to detect their external existence, so that apparently they are not produced in the source. If we are to assume that the tones received by the ear are pure and free from partials, the loudness of the beat-tones would appear to show that Helmholtz's theory is not a complete account.

(3) The third mode of production of combination tones, the production in the medium itself, follows from the varying velocity of different parts of the wave, as investigated at the beginning of this article. It is easily shown that after a time we shall have to superpose on the original displacement a displacement proportional to the square of the particle velocity, and this will introduce just the same set of combination tones. But probably in practice there is not a sufficient interval between source and hearer for these tones to grow into any importance, and they can at most be only a small addition to those formed in the source or the ear.

AUTHORITIES.—LORD RAYLEIGH, *Sound*, 2nd ed. London, 1894, is the standard treatise on the phenomena of Acoustics; the last chapter, on "Facts and Theories of Audition," is a most valuable summary of the present state of knowledge of audition and the different theories held.—HELMHOLTZ, *Sensations of Tone*, 2nd Eng. ed. London, 1885, deals more with the physiological aspect.—SEDLEY TAYLOR, *Sound and Music*, London, 1873, is a general

account of Helmholtz's Theory of Consonance and Dissonance (briefly stated in O. A. § 106, but not discussed in this supplement).—POYNTING and THOMSON, *Sound*, London, 1899, is an elementary mathematical account of the phenomena of Acoustics.
(J. H. P.*)

Acqui, a town and episcopal see of the province of Alessandria, Piedmont, Italy, 21 miles S.S.W. from Alessandria by rail. The castle of the Palæologi is now converted into a prison. Here is a technical school. Its sulphur baths attract annually about 4000 visitors. Population (1901), 13,786.

Acre (Arab. *Åkka*), a survival of the Biblical *Acco*, and ancient *Ake*, the chief town of a Palestine sanjak which includes Haifa, Nazareth, and Tiberias. From its commanding position on the sea-shore of a broad fertile plain over which the coast road from Syria to Egypt has always passed, and whence there is easy access to the rich lands of Galilee and the Trans-Jordanic countries, it has been called "the Key of Palestine," and its history is principally that of its many sieges. It was occupied in turn by Assyrians, Babylonians, Persians, and Greeks, but never by the Hebrews, and was assigned on the division of Alexander's kingdom to Ptolemy Soter, after whom it was called *Ptolemais*. One of its mediæval names, *Acon*, has been preserved in that of the church of St Nicholas Acons, in Lombard Street, London. It exports wheat, maize, olive oil, cotton, &c., but the trade is gradually passing to Haifa, where there is a safer roadstead. The town will be connected by a branch line with the Haifa-Damascus railway now being constructed. Population, 11,000 (Moslems, 8000; Christians, Jews, and others, 3000).

Actinozoa. See ANTHOZOA.

Acton, a parish and urban district (coextensive) in the suburbs of London, in the Ealing parliamentary division of Middlesex, about 7 miles W. of St Paul's, with three railway stations. Many distinguished persons have lived there, among them Richard Baxter, Sir Matthew Hale, Henry Fielding, and Lindley the botanist. A recreation ground of 21 acres was opened in 1887, and there are a cottage hospital, a free library (1900), and a Thomas Aske girls' school (1901). Area, 2305 acres. Population (1881), 17,110; (1891), 24,206; (1901), 37,744.

Acton, John Emerich Edward Dalberg Acton, 1st BARON (1834-1902), son of Sir Ferdinand Acton, Bart., was born at Naples, 10th January 1834. His mother, who after her husband's death in 1837 married Earl Granville, was the daughter of the duke of Dalberg, which caused Lord Acton, after studying under Cardinal Wiseman at the Roman Catholic college at Oscott, to receive the most valuable part of his education in Bavaria. Under the inspiration of Döllinger, in whose house he lived for a considerable time, he imbibed not only that love of history, but that disposition to treat history as a science in a thoroughly impartial spirit, and to render a profound investigation of canon and of international law auxiliary to historical research, which afterwards distinguished him. Such a spirit must be one of especial hostility to ultramontane pretensions; and Lord Acton, although a sincere Catholic, made it for a time his especial mission to combat these in the *Home and Foreign Review*, which he conducted from 1862 to 1864 with a vigour insuring its condemnation and virtual suppression by the Roman Catholic hierarchy. Nothing daunted, Lord Acton and his friends acquired the *North British Review*, hitherto an organ of the Free Church of Scotland, and carried it on actively for several years in the interest of a high-class Liberalism both in temporal and in ecclesiastical matters. Lord Acton contributed several valuable articles, and in 1870 proceeded to Rome to take such part as was possible to a layman in opposing the promulgation of the dogma of papal infallibility. He was active as a writer under his own name and as an inspirer of the writings of others, but the calamity so much dreaded by Liberal Catholics was not to be averted. The Old Catholic separation followed, but Lord Acton held aloof. He had been raised to the peerage in 1869, but his great knowledge and breadth of view were too little enlisted in the service of the House of Lords. In 1874, however, he came forward conspicuously as a supporter of Mr Gladstone in the controversy on "Vaticanism," pointing out in a series of letters to the *Times* various actions and characteristics of individual popes by no means easy to reconcile with the doctrine of papal infallibility. For many years little came from his pen except an article on the divorce of Henry VIII. in the *Quarterly Review* for 1877, and an essay on modern German historians, contributed to the first number of the *English Historical Review* in 1886. In 1895, however, his acceptance of the Regius Professorship of Modern History at Cambridge, vacant by the death of Sir John Seeley, drew from him an inaugural lecture on "The Study of History," with notes displaying a vast erudition, by no means merely historical. Lord Acton continued to lecture at Cambridge, and, at the instance of the university, undertook the editorship of a great modern history by various writers from the middle of the 15th century to the present day. Lord Acton was an Honorary Fellow of All Souls' college, Oxford, and was a lord-in-waiting from 1892 to 1895. He died on 19th June 1902.

Acts of the Apostles.—In this article we shall deal with such additions to our knowledge as have been made since 1875, when the article in the ninth edition of this work was published.

Text.—The apparatus criticus of Acts has grown considerably of recent years; yet mainly in one direction, that of the so-called "Western" text. This term, which our growing knowledge, especially of the Syriac and other Eastern versions, is rendering more and more unsatisfactory, stands for a text which used to be connected almost exclusively with the "eccentric" *Codex Bezæ*. But it is now recognized to have been very widespread, both in east and west, for some 200 years or more from about the middle of the 2nd century. The process, however, of sifting out the readings of all our present witnesses—MSS., versions, fathers—has not yet gone far enough to yield any sure or final result as to the history of this text, so as to show what in its extant forms is primary, secondary, and so on. Beginnings have been made towards grouping our authorities; but the work must go on much further before a solid basis for the reconstruction of its primitive form can be said to exist. The attempts so far made at such a reconstruction, as by Blass (1895, 1897) and Hilgenfeld (1899), are quite arbitrary. And the like must be said of the most recent contribution to the problem, that of August Pott,[1] though he has helped to define one condition of success—the classification of the strata in "Western" texts—and has taken some steps in the right direction, in connexion with the complex phenomena of one witness, the Harklean Syriac.

Assuming, however, that the original form of the "Western" text had been reached, the question of its historical value, *i.e.*, its relation to the original text of Acts, yet remains. On this point the highest claims have recently been made by Blass. Ever since 1894 he has held that both the "Western" text of Acts (which he styles the β text) and its rival, the text of the great uncials

---

[1] *Der abendländische Text der Apostelgeschichte u. die Wir-quelle.* Leipzig, 1900.

(which he styles the *a* text), are due to the author's own hand. Further, that the former is the more original of the two, being related to the latter as fuller first draft to severely pruned copy. But even in its latest form, that "*β* stands nearer the *Grundschrift* than *a*, but yet is, like *a*, a copy from it," the theory is really untenable. In sober contrast to Blass' sweeping theory stand the views of Prof. W. M. Ramsay. Already in *The Church in the Roman Empire* (1893) he held that the *Codex Bezæ* rested on a recension made in Asia Minor (somewhere between Ephesus and S. Galatia), not later than about the middle of the 2nd century. Though "some at least of the alterations in *Codex Bezæ* arose through a gradual process, and not through the action of an individual reviser," the revision in question was the work of a single reviser, who in his changes and additions expressed the local interpretation put upon Acts in his own time. His aim, in suiting the text to the views of his day, was partly to make it more intelligible to the public, and partly to make it more complete. To this end he "added some touches where surviving tradition seemed to contain trustworthy additional particulars," such as the statement that Paul taught in the lecture-room of Tyrannus "from the fifth to the tenth hour." In his later work, on *St Paul the Traveller and the Roman Citizen* (1895), Ramsay's views gain both in precision and in breadth. The gain lies chiefly in seeing beyond the Bezan text to the "Western" text as a whole. But when he writes that, "wherever the Bezan text is confirmed by old versions and by certain Greek MSS., it seems to me to deserve very earnest consideration, as at least pointing in the direction of an original reading subjected to widespread corruption," he goes beyond the mark. Such agreement need not mean more than that the reading is a gloss belonging to the "Western" text, as it arose under conditions which Ramsay himself excellently describes.

On the whole, then, the text of Acts as printed by Westcott and Hort, on the basis of the earliest MSS. (אB), seems as near the autograph as that in any other part of the New Testament; whereas the "Western" text, even in its earliest traceable forms, is secondary. This does not mean that it has no historical value of its own. It may well contain some true supplements to the original text, derived from local tradition or happy inference; certain of these may even date from the end of the 1st century, and the larger part of them are probably not later than the middle of the 2nd. But its value lies mainly in the light cast on the ecclesiastical tradition in certain quarters during the epoch in question. The nature of the readings themselves, and the distribution of the witness for them, alike point to a process involving several stages and several originating centres of diffusion. The classification of groups of "Western" witnesses has already begun. When completed, it will cast light, not only on the origin and growth of this type of text, but also on the exact value of the remaining witnesses to the original text of Acts.

Plan and Object of Acts.—Here the Tübingen school did its chief work in putting the needful question, not in returning the correct answer. Their answer could not be correct, because, as Ritschl shows, their premises were wrong. Still the attitude created by the Tübingen theory largely persists as a biassing element in much that is written about Acts. On the whole, however, there is a disposition to look at the book more objectively, and to follow up the hints as to its aim given by the author in his opening verses. Thus (1) his second narrative is the natural sequel to his first. As the earlier one set forth in orderly sequence (καθεξῆς) the providential stages by which Jesus was led, "in the power of the Spirit," to begin the establishment of the consummated Kingdom of God; so the later work aims at setting forth on similar principles its extension by means of His chosen representatives or apostles. This involves emphasis on the identity of the power, *i.e.*, divine and not merely human power, expressed in the great series of facts from first to last, and so upon (2) the Holy Spirit, as directing and energizing throughout the whole struggle with the powers of evil to be overcome in either ministry, of Master or disciples. But (3) the continuity is more than similarity of activity, resting on the same divine energy. The working of the energy in the disciples is conditioned by the continued life and volition of their Master at His Father's right hand in heaven. The living link between Master and disciples is the Holy Spirit, "the Spirit of Jesus." Hence the pains taken to exhibit afresh (i. 2, 4 f. 8, ii. 1 ff., *cf.* Luke xxiv. 49) the fact of such spiritual solidarity, whereby their activity means His continued action in the world. And (4) the scope of this action is nothing less than humanity as gathered within the Roman empire. It was foreordained that Messiah's witnesses should be borne by divine power through all obstacles and to ever-widening circles, until they reached and occupied Rome itself for the God of Israel—now manifest (as foretold by Israel's own prophets) as the one God of the one race of mankind. (5) Further, as we gather from the parallel account in Luke xxiv. 46-48, the divinely appointed method of victory is through suffering (Acts xiv. 22). This thought explains the large space devoted to the tribulations of the witnesses, and their constancy amid them, after the type and sample of their victorious Lord. It forms one side of the virtual *apologia* for the absence of that outward prosperity in which the pagan mind was apt to see the token of divine approval. Another side is the recurring exhibition of the fact that these witnesses were persecuted only by those whose action should create no bias against the persecuted. Their foes were chiefly Jews, whose opposition was due partly to a stiff-necked disinclination to bow to the wider reading of their own religion—to which the Holy Spirit had from of old been pointing—and partly to jealousy of those who, by preaching the wider Messianic Evangel, were winning over the Gentiles, and particularly proselytes, in such great numbers.

Such, then, seem to be our author's main *motifs*. They make up an account fairly adequate to the manifoldness of the book; and yet they all run up into one central idea, viz., the divine character of the Christian religion, as evinced by the manner of its extension in the empire. This view has the merit of giving the book a practical religious aim—a *sine quâ non* to any theory of an early Christian writing. Though addressed to men of pagan birth in the first instance, it is to them as inquirers or even recent converts, such as "Theophilus," that the appeal is made. In spite of all difficulties, this religion is worthy of personal belief and acceptance. Such is the moral of our author's work. Yet among the conditioning features of the occasion, which impressed him with the need of such an appeal, was doubtless the existence of persecution now actually carried out by the Roman authorities, sometimes perhaps of their own motion. To meet this special perplexity our author holds up the picture of early days, when the great protagonists of the Gospel constantly enjoyed protection at the hands of Roman justice. It is implied that the present distress was but a passing phase, resting on some misunderstanding; meantime, the spectacle of apostolic constancy should yield strong consolation to the tried.

From this standpoint Acts no longer seems to end abruptly. Whether as exhibiting marvellous divine leading and aid, or as recording the impartial and even kindly attitude of the Roman state towards the Christians, the writer has reached a climax. "He wished," as Harnack well remarks, "to point out the might of the Holy Spirit in the apostles, Christ's witnesses; and to show how this might carried the Gospel from Jerusalem to Rome and gained for it entrance into the pagan world, whilst the Jews in growing degree incurred rejection. In keeping with this, verses 26-28 of chapter xxviii. are the solemn closing verses of the work. But verses 30, 31 are an appended observation." So far, so good; but objection may be taken when Harnack goes on to say that this observation does not admit of explanation from the plan of the work, "but rather from the almost independent interest which, not so much the life of Paul, as the marvellous manner of the realization of Paul's journey to Rome had incidentally acquired for the author." To many it will seem that the writer is ending up most fitly on one of his keynotes, in that he leaves Paul preaching in Rome itself, "unmolested." The full force of this is missed by those who, while rejecting the idea that the author had in reserve enough Pauline history to furnish another work, yet hold that Paul was freed from the imprisonment amid which Acts leaves him.[1] But for those, on the other hand, who see in the writer's own words in xx. 38, uncontradicted by anything in the sequel, a broad hint that Paul never saw his Ephesian friends again, the natural view is open that the sequel to the two years' preaching was too notorious to call for explicit record. Nor would such silence touching Paul's speedy martyrdom be disingenuous, any more than on the theory that martyrdom overtook him several years later. Our author would view Paul's death as a mere exception to the rule of Roman policy heretofore illustrated, due to the influence of a sort of madman, such as Nero was naturally held to be in the latter part of his reign. Not even by the Roman authorities were some of his acts regarded as precedents; and so our author could honestly refrain from recording what he viewed as a mere freak of Neronian caprice, especially as it would be already known to his contemporaries. Such silence would be the more natural if he were writing in Rome, a conclusion to which certain things are often thought to point.

Date.—External evidence now points to the existence of Acts at least as early as the opening years of the 2nd century. As evidence for the Third Gospel holds almost equally for Acts, its existence in Marcion's day (120-140) is now assured. Further, the traces of it in Polycarp[2] and Ignatius,[3] when taken together, are highly probable. And what is still more important, it is probable that Acts was already known in Rome by *c.* A.D. 96. For it is widely admitted that the resemblance of Acts xiii. 22, and 1 Clem. xviii. 1, in features not found in the Psalm (lxxxix. 20) quoted by each, cannot be accidental.

Acts xiii. 22.	1 Clem. xviii. 1.
ἤγειρεν τὸν Δαυεὶδ . . . ᾧ καὶ εἶπεν μαρτυρήσας, Εὗρον Δαυεὶδ τὸν τοῦ Ἰεσσαί, ἄνδρα κατὰ τὴν καρδίαν μου [*ἄνδρα κ.τ.λ.* from 1 Sam. xiii. 14, *ἄνθρωπον κ.τ.λ.*].	*Τί δὲ εἴπωμεν ἐπὶ τῷ μεμαρτυρημένῳ Δαυείδ; πρὸς ὃν εἶπεν ὁ θεός, Εὗρον ἄνδρα κατὰ τὴν καρδίαν μου, Δαυεὶδ τὸν τοῦ Ἰεσσαί, ἐν ἐλέει αἰωνίῳ ἔχρισα αὐτόν.*

Here the Greek Bible has simply *Εὗρον Δαυεὶδ τὸν δοῦλόν μου.* Nor should the reference in either case to David as a man witnessed to by God, be overlooked, tending as it does to exclude the idea that the likeness between the passages is due to some third source. The dependence seems clearly to be on the side of 1 Clement, especially in view of possible echoes of Acts xx. 35, which it contains in three distinct places (ii. 1, xiii. 1, xlvi. 7, *cf.* Polyc. ii. 3). There is, then, high probability that Acts was current in Antioch and Smyrna not later than *c.* A.D. 115, and in Rome as early *c.* A.D. 96.

With this view internal evidence agrees. In spite of Blass' advocacy of a date prior to A.D. 70, the bulk of critical opinion puts this theory firmly aside. Thus the prologue to the Gospel of which Acts is the sequel, already implies the dying out of the generation of eye-witnesses as a body. Of recent years, too, the relations of Church and Empire have been brought to bear, especially by Ramsay. And his dating, A.D. 81 or soon after, fits in with a strong consensus of critical opinion both in England and abroad—Harnack, for instance, placing Acts between 80 and 93, while Zahn prefers 75 to 80. So that A.D. 80 may be taken as a fair average date, while any year between it and 71 is open. Of the reasons for a date in one of the earlier decades of the second century, as argued by the Tübingen school and its heirs, several are now really untenable. Among these are the supposed traces of 2nd-century gnosticism and "hierarchical" ideas of organization; but especially the argument from the relation of the Roman state to the Christians, which Ramsay has completely reversed and turned into proof of an origin prior to Pliny's correspondence with Trajan on the subject. Another fact, now generally admitted, renders a 2nd-century date yet more incredible; and that is, the failure of a writer devoted to Paul's memory to make palpable use of his Epistles. Instead of this he writes in a fashion that seems to traverse certain facts recorded in them. If, indeed, it were proved that Acts uses the later works of Josephus, we should have to place the book about A.D. 100. But this is far from being the case, a critic like Harnack decisively rejecting the alleged dependence.

Sources.—So far from the recognition of a plan in Acts being in itself inimical to a serious quest after the materials used in its composition, one may say that it points the way thereto, while it keeps the literary analysis within scientific limits. Thus the more one realizes the theological standpoint of the mind pervading the book as a whole, the more one feels that the speeches in the first part of Acts—and indeed elsewhere, too—are not "free compositions" of our author, the outcome of dramatic idealization such as ancient historians like Thucydides or Polybius allowed themselves. The Christology, for instance, of the early Petrine speeches is such as a Gentile Christian writing *c.* 80 A.D. simply could not have imagined, even had the idea of adopting Judæo-Christian categories been present to his mind. Thus we are forced to assume the use of a certain amount of early Judæo-Christian material, analogous to that implied also in the special parts of the Third Gospel. One critic, at least, Paul Feine (*Eine vorkanonische Ueberlieferung des Lukas*, 1891), suggests that a single document explains this material in both works, as far as Acts xii.; while others maintain that more than one such source underlies Acts i.-xii., or even i.-xv. (*e.g.*, a source embodying the traditions of the largely Gentile Church of Antioch). Yet if our author was an Antiochene and a careful inquirer (Luke i. 3), this may explain all. It cannot, indeed, be said that definite results have here been attained as yet. But the study is a new one, and the resources of analysis, the linguistic in particular, are by no means exhausted. One important analogy for the way in which one author may be supposed to have handled his sources exists; and that is the manner in which he uses Mark's narrative in compiling his own Gospel.

---

[1] Unless we arbitrarily separate (in the face of the ancient Latin version) *ἐπὶ τὸ τέρμα τῆς δύσεως ἐλθών*, from *καὶ μαρτυρήσας ἐπὶ τῶν ἡγουμένων οὕτως ἀπηλλάγη τοῦ κόσμου*, 1 Clement v. 7 gives no support to this idea; while the next chapter seems clearly to put Paul's death not later than the Neronian persecution of A.D. 64.

[2] Polyc. *ad Philipp.* i. 2, Acts ii. 24; ii. 1, Acts x. 42; ii. 3, Acts xx. 35; vi. 3, Acts vii. 52.

[3] Ign. *ad Magn.* v. 1, Acts i. 25; *ad Smyrn.* iii. 3, Acts x. 41.

Guided by such an objective criterion, and safeguarded by growing insight into the author's plastic aim, we need not despair of reaching large agreement as to the main scope of the sources lying behind the first half of Acts.

In the second or strictly Pauline half we are confronted by the so-called "we" passages. Of these two main theories are possible; that which sees in them traces of an earlier document—whether entries in a travel-diary, or a more or less consecutive narrative written later; and that which would regard the "we" as due to the author's breaking instinctively into the first person plural at those points in the history at which he himself had been present. On the former hypothesis, it is still in debate whether the "we" document does or does not lie behind more of the narrative than is definitely indicated by the formula in question (*e.g.*, cc. xiii.-xv., xxi. 19-xxvi.)

Authorship.—Was the author of the "we" passages, in any form, also the author of Acts as it now stands? And if so, was that author's name Luke, as ecclesiastical tradition has steadily affirmed from the time when its voice first reaches us? Few deny that Luke, *i.e.*, Paul's companion of that name, was the author of the "we" passages. The tradition connecting him with Acts is too early and unanimous to be mistaken, especially seeing that his name was not prominent enough to account for such an ascription by "spontaneous generation." Hence those who would see in the "we" passages traces of an earlier travel-document written by Timothy or Silas, seem bound in a special degree to make Luke the author of Acts as a whole. In this case, however, they have yet to explain how so skilled a writer, one elsewhere master of his sources as to literary form, could leave these sections couched in the first person of the eye-witness. And it may fairly be said that, if the weight of expert opinion is against the theory of literary negligence, it inclines also against the theory of pious fraud—the retention of the first person with intent to deceive. The net result is, that unity of authorship between the "we" passages and the rest of Acts seems the one tenable view; and this involves the Lucan authorship of both.[1] As to such historical difficulties in Acts as at present perplex the student of the apostolic age, one must remember in most cases the possibilities of mistake intervening between the facts and the accounts reaching its author at second or even third hand. Yet it must be strongly emphasized that recent historical research at the hands of experts in classical antiquity has tended steadily to verify such parts of the narrative as it can test. That is no new result; but it has come to light in greater degree of recent years, and notably during the last decade. The proofs of our author's trustworthiness extend also to the theological sphere. What was said above of the Christology of the Petrine speeches, applies also to the whole conception of Messianic salvation, the eschatology, the idea of Jesus as equipped by the Holy Spirit for His Messianic work, found in these speeches, as also to titles like "Jesus the Nazarene" and "the Righteous One" both in and beyond the Petrine speeches. These and other cases in which we are led to discern Judæan witness behind Acts, do not indeed give to such witness the value of shorthand notes or even of abstracts based thereon. But they do support the theory that our author meant to give an unvarnished account of such words and deeds as had come to his knowledge. The perspective of the whole is no doubt his own; and as his witnesses probably furnished but few hints for a continuous historical narrative, this perspective, especially in things chronological, may sometimes be faulty. Yet when one remembers that by 80 A.D. it must have been a matter of small interest by what tentative stages the Messianic salvation first extended to the Gentiles, it is surely surprising that Acts enters into such detail on the subject, and is not content with a summary account of the matter such as the mere "logic" of the subject would naturally suggest. In any case the very difference of the perspective of Acts and of Galatians, in recording the same epochs in Paul's history, argues such an independence in the former as is compatible, in the case of an admirer of the apostle, only with an early date, when as yet Galatians might easily be unknown beyond the district to which it was addressed.[2]

Quellenkritik, then, a distinctive feature of recent research upon Acts, is a solvent of many difficulties in the way of treating Acts as an honest narrative by a companion of Paul. It will account, for instance, for such discrepancies as lie on the surface of the three accounts of Saul's conversion; while the fidelity with which our author uses his materials is shown by his not assimilating the accounts in Paul's speeches to the earlier narrative in chapter ix. In addition to *Quellenkritik*, we may also count among recent gains a juster method of judging such a book. For among the results of the Tübingen criticism was what Dr Sanday calls "an unreal and artificial standard, the standard of the 19th century rather than the 1st, of Germany rather than Palestine [may we not add Antioch or Rome?], of the lamp and the study rather than of active life." In the recovery of a more real standard, we owe much to men like Mommsen, Ramsay, and Blass, trained amid other methods and traditions than those which had brought the constructive study of Acts almost to a deadlock.

LITERATURE.—It would take too much space to give an account of the extensive and varied literature that gathered round Acts during the last quarter of the 19th century. It may be found in two recent and representative commentaries, viz., Wendt's last edition of Meyer (1899), and that by R. J. Knowling in *The Expositor's Greek Testament*, vol. ii. 1900. (J. V. B.)

Adabazár, an important commercial town in Asia Minor, situated on the old military road from Constantinople to the east, and 5½ miles distant from a station of the same name on the Anatolian railway. It was founded in 1540 and enlarged in 1608 by the settlement in it of an Armenian colony. There are silk and linen industries, and an export of tobacco, walnut-wood, cocoons, and vegetables for the Constantinople market. Imports are valued at £80,000, and exports at £480,000. Population, 18,000 (Moslems, 10,000; Christians, 8000).

Adalia, or ANTALIA, classical *Attaleia*, mediæval *Satalia*, the chief town and seaport of a sanjak of the Konia viláyet in Asia Minor. It is situated at a re-entering angle, in a flat limestone terrace which terminates seaward in a cliff about 120 feet high, and had an inner and outer harbour. The town lies partly within and partly without the old walls, in which may still be seen the Perga Gate, built by Hadrian, a tower erected by the Empress Julia, and many Greek and Latin inscriptions. There are several mosques and medresses (or schools) built by the Seljúk sultans of Rúm, and a few remains of Roman and Byzantine buildings.

Attaleia was founded, 159-138 B.C., to facilitate trade between the Pergamene kingdom and Syria and Egypt. Under the Romans it was an important town, connected by highways with Laodicea and Pisidian Antioch, and the centre of a large sea-borne trade. It became the metropolis of Pamphylia, and in 1148 it gave timely shelter to the harassed troops that Louis VII. of France was leading to Palestine. Afterwards it passed to the Seljúk Turks, 1206; to the Venetians, 1307; to the Mongols, the Genoese, and finally to the Osmanli Sultan Murad II. (1421-51). Adalia has lost much of its trade since the opening of railways from Smyrna to the interior, but it still exports cereals, timber, valonea, liquorice root, and cotton: the exports in 1899 were valued at £152,156, the imports at £120,073. It is the seat of a British vice-consulate. Population, 30,000 (Moslems, 24,000; Christians, many apparently of Jewish origin, 6000).

---

[1] This accords excellently with the reference in Col. iv. 14 to Luke as a physician. For a good account of the argument from the medical language of Acts, see Knowling, *Expositor's Greek Testament*, vol. ii. 9-11.

[2] Nor should one forget the numerous but subtle agreements between Acts and Galatians which Ramsay has shown to be involved in the now victorious "South Galatian" theory, that sees in St Paul's "Galatians" the members of the churches whose foundation is described in Acts xiii. xiv.

Adamawa, a country of West Africa, now divided between the British colony of Nigeria (which includes the chief town, Yola) and the German colony of Cameroon. Recent estimates place the height of the granite range of Alantika, the loftiest point in the country, at only 6000 feet. The pagan negro tribes have been dominated by the Mahommedan Fullas, so widely spread over West and Central Africa, for about four centuries. There are also in the country to-day large numbers of Haussas, who continue to push southwards as traders, as well as Arabs and Kanuri. The Emir of the state of Yola formerly claimed rights of suzerainty over the whole of Adamawa, but the country now consists of a number of separate sultanates which are gradually being brought under the influence of the British and Germans. The town of Garua on the Upper Benue is one of the principal trade centres in the north, and that of Yoko one of the principal in the south. After Barth, the first traveller to penetrate Adamawa was the German, E. R. Flegel (1882), but the country has since been traversed by many expeditions, especially that of Uechtritz and Passarge (1893-94). (See especially PASSARGE. *Adamaua.* Berlin, 1895.)

Adams, a town in Berkshire county, in the northwestern part of Massachusetts, U.S.A., having an area of 23 square miles. It includes a portion of the valley of Hoosac river, extending to the Hoosac range on the east, and on the west to Greylock mountain, the highest point in the state, having an altitude of 3505 feet. The valley portion is level and contains several villages, the largest of which bears the same name as the town. Adams village is on a branch of the Boston and Albany railroad, is irregularly laid out, and has an altitude above sea of 798 feet. The town was incorporated in 1778. The population in 1880 was 5591; in 1890 it was 9213, and in 1900 it was 11,134.

Adams, Charles Francis (1807-1886), American diplomatist, son of John Quincy Adams, and grandson of John Adams, was born in Boston on the 18th of August 1807. His father, having been appointed minister to Russia, took him to St Petersburg, where he acquired a perfect familiarity with French, learning it as his native tongue. After eight years spent in Russia and England, he attended Harvard College, and graduated there at eighteen. Then he lived two years in the White House, Washington, during the presidency of his father, studying law and moving in society, where he met Webster, Clay, Jackson, and Randolph. Returning to Boston he devoted ten years to business and study, and wrote for the *North American Review.* He also undertook the management of his father's pecuniary affairs, and actively supported him in his contest in the House of Representatives for the right of petition and the anti-slavery cause. In 1848 he was prominent in politics as a "Conscience Whig," presiding over the Buffalo Convention which formed the Free Soil party and nominated Van Buren for president and himself for vice-president. As a member of the House of Representatives in that Congress which sat from 3rd December 1860 to 4th March 1861, he represented Massachusetts in the committee of thirty-three at the time of the secession of seven of the Southern States. His selection by the chairman of this committee to present to the full committee certain propositions agreed upon by two-thirds of the republican members, and his calm and able speech of 31st January 1861 in the House, served to make him conspicuous before Congress and the country. Together with Seward, he stood for the republican policy of concession; and, while he was criticized severely, and charged with inconsistency in view of his record as a Conscience Whig, he was of the same mind as Lincoln, willing to concede nonessentials, but holding rigidly to the principle, properly understood, that there must be no extension of slavery. He believed that as the republicans were the victors they ought to show a spirit of conciliation, and that the policy of righteousness was likewise one of expediency, since it would have for its result the holding of the border slave States with the North until 4th March, when the republicans could take possession of the Government at Washington. With the incoming of the new administration Secretary Seward secured for Adams the appointment of minister to Great Britain. So much sympathy was shown in England for the southern cause that his path was beset with difficulties; but his mission was to prevent the interference of Great Britain in the struggle; and while the work of Lincoln, Seward, and Sumner, and the cause of emancipation, tended to this end, the American minister was insistent and unyielding, and knew how to present his case forcibly and with dignity. He laboured with energy and discretion to prevent the escape of the *Alabama;* and, when unsuccessful in this, he persistently urged upon the British Government its responsibility for the destruction of American merchant vessels by that cruiser. His reserve and frigidity, enforced by his diplomatic ability and high character, procured him the respect of the English, and were of marked assistance to him in his ministerial and social duties. In many emergencies he displayed coolness and courage of a high order. In his own diary he shows that underneath the calm exterior were serious trouble and keen anxiety; and, in fact, the strain which he underwent during the Civil war made itself felt in later years. Adams was instrumental in getting Earl Russell to stop the *Alexandra*, and it was his industry and pertinacity in argument and remonstrance that induced Russell to order the detention in September 1863 of the two ironclad rams intended for the Southern Confederacy. Adams remained in England until May 1868. His last important work was as a member of the Tribunal of Arbitration at Geneva, which disposed of the "*Alabama* claims." His knowledge of the subject, and his fairness of mind, enabled him to render his country and the cause of international arbitration valuable service. He died at Boston on the 21st of November 1886.

An excellent biography of him has been written by his son, CHARLES F. ADAMS, in the *American Statesmen* series (1900). For his labours in editing works and memoirs, his private speeches and honorary degrees, see *Memoir* in *Massachusetts Historical Society Proceedings*, October 1899. (J. F. R.)

Adams, John Couch (1819-1892), British astronomer, was born at Lidcot farmhouse, Laneast, Cornwall, on 5th June 1819. His father, Thomas Adams, was a tenant farmer; his mother, Tabitha Knill Grylls, inherited a small estate at Badharlick. From the village school at Laneast he went, at the age of twelve, to Devonport, where his mother's cousin, the Rev. John Couch Grylls, kept a private school. His promise as a mathematician induced his parents to send him to the University of Cambridge, and in October 1839 he entered as a sizar at St John's College. He graduated B.A. in 1843 as the senior wrangler and first Smith's prizeman of his year. While still an undergraduate he happened to read of certain unexplained irregularities in the motion of the planet Uranus, and determined to investigate them as soon as possible, with a view to ascertaining whether they might not be due to the action of an undiscovered planet beyond it. Elected fellow of his college in 1843, he at once proceeded to attack the novel problem. It was this: from the observed perturbations of a known planet to deduce by calculation, assuming only Newton's law of gravitation, the mass and orbit of an unknown disturbing body. By September 1845 he obtained his first solution, and handed to Professor Challis, the director of the Cambridge Observatory, a paper giving the elements of what he described as "the new planet." On 21st October 1845 he left at Greenwich Observatory, for the information of Airy, the astronomer royal, a similar document, still preserved among the archives. A fortnight afterwards Airy wrote asking a question about a point in the solution. Adams, who thought the point trivial, did not reply, and Airy for some months took no steps to verify by telescopic search the results of the young mathematician's investigation. Meanwhile, Le Verrier, on 10th November 1845, presented to the French Academy a memoir on Uranus, showing that the existing theory failed to account for its motion. Unaware of Adams's work, he attempted a like inquiry, and on 1st June 1846, in a second memoir, gave the position, but not the mass or orbit, of the disturbing body whose existence was presumed. The longitude he assigned differed by only 1° from that predicted by Adams in the document which Airy possessed. The latter was struck by the coincidence, and mentioned it to the Board of Visitors of the Observatory, Challis and Herschel being present. Herschel, at the ensuing meeting of the British Association early in September, accordingly ventured to predict that a new planet would shortly be discovered. Meanwhile Airy had in July suggested to Challis that the planet should be sought for with the Cambridge equatorial. The search was begun by a laborious method at the end of the month. On 4th and 12th August, as afterwards appeared, the planet was actually observed; but owing to the want of a proper star-map it was not then recognized as planetary. Le Verrier, still ignorant of these occurrences, presented on 31st August 1846 a third memoir, giving for the first time the mass and orbit of the new body. He communicated his results by letter to Dr Galle, of the Berlin Observatory, who at once examined the suggested region of the heavens. On 23rd September he detected near the predicted place a small star unrecorded in the map, and next evening found that it had a proper motion. No doubt remained that "Le Verrier's planet" had been discovered. On the announcement of the fact Herschel and Challis made known that Adams had already calculated the planet's elements and position. Airy at length published an account of the circumstances, and Adams's memoir was printed as an appendix to the *Nautical Almanac*. A keen controversy arose in France and England as to the merits of the two astronomers. In the latter country much surprise was expressed at the apathy of Airy; in France the claims made for an unknown Englishman were resented as detracting from the credit due to Le Verrier's achievement. As the indisputable facts became known, the world recognized that the two astronomers had independently solved the problem of Uranus, and to each ascribed an equal glory. The new planet, at first called *Le Verrier* by Arago, received by general consent the neutral name of *Neptune*. Its mathematical prediction was not only an unsurpassed intellectual feat; it showed also that Newton's law of gravitation, which Airy had almost called in question, prevailed even to the utmost bounds of the solar system.

The honour of knighthood was offered to Adams when Queen Victoria visited Cambridge next year; but then, as on a subsequent occasion, his modesty led him to decline it. The Royal Society awarded him its Copley medal in 1848. In the same year the members of St John's College commemorated his success by founding in the University an Adams prize, to be given biennially for the best treatise on a mathematical subject. In 1851 he became president of the Royal Astronomical Society. His lay fellowship at St John's College came to an end in 1852, and the existing statutes did not permit of his re-election. Pembroke College, which possessed greater freedom, elected him in the following year to a lay fellowship, and this he held for the rest of his life. In 1858 he became professor of mathematics at St Andrews, but lectured only for a session, when he vacated the chair for the Lowndean professorship of astronomy and geometry at Cambridge. Two years later he succeeded Challis as director of the Observatory, where he resided until his death. In 1863 he married Miss Eliza Bruce, of Dublin, who survived him.

Although Adams's researches on Neptune were those which attracted widest notice, the work he subsequently performed in relation to gravitational astronomy and terrestrial magnetism was not less remarkable. Several of his most striking contributions to knowledge originated in the discovery of errors or fallacies in the work of his great predecessors in astronomy. Thus in 1852 he published new and accurate tables of the moon's parallax, which superseded Burckhardt's, and supplied corrections to the theories of Damoiseau, Plana, and Pontécoulant. In the following year his memoir on the secular acceleration of the moon's mean motion disproved the validity of Laplace's famous explanation, which had held its place unchallenged for sixty years. At first, Le Verrier, Plana, and others abroad disputed the soundness of Adams's startling result; but further inquiry established beyond question that he was right, and his memoir produced nothing less than a revolution in this branch of theoretical astronomy. The Royal Astronomical Society in 1866 awarded him its gold medal for these researches. The great meteor shower of 1866 turned his attention to the Leonids, whose probable path and period had already been discussed by Professor H. A. Newton. Using a powerful and elaborate analysis, Adams ascertained that this cluster of meteors, which belongs to the solar system, traverses a nearly circular orbit in 33¼ years, and is subject to definite perturbations from the larger planets, Jupiter, Saturn, and Uranus. These results were published in 1867. Ten years later, when Mr G. W. Hill of Washington brought out a new and beautiful method for dealing with the problem of the lunar motions, Adams announced in a brief notice his own work in the same field, which had followed a parallel course. His results confirmed and supplemented Hill's. In 1874-76 he was president of the Royal Astronomical Society for the second time, when it fell to him to present the gold medal of the year to Le Verrier. The determination of the constants in Gauss's theory of terrestrial magnetism occupied him at intervals for over forty years. The calculations involved great labour, and were not published during his lifetime. They were edited by his brother, Professor W. Grylls Adams, and appear in the second volume of the collected *Scientific Papers*. Numerical computation of this kind might almost be described as his pastime. The value of the constant known as Euler's, and the Bernoullian numbers up to the 62nd, he worked out to an unimagined degree of accuracy. For Newton and his writings he had a boundless admiration; many of his papers, indeed, bear the cast of Newton's thought. He laboured for many years at the task of arranging and cataloguing the great collection of Newton's unpublished mathematical writings, presented in 1872 to the University by Lord Portsmouth. The account of these, issued in a volume by the University Press in 1888, is by his hand. The post of Astronomer Royal was offered him in 1881, but he preferred to pursue his peaceful course of teaching and research in Cambridge. He was British delegate to the International Prime Meridian Conference at Washington in 1884, when he also attended the meetings of the British Association at Montreal and of the American Association at Philadelphia. Five years later his health gave way, and after a long illness he died at the Cambridge Observatory on 21st January 1892, and was buried in St Giles' cemetery, near his home. An international committee was formed for the purpose of erecting a monument to his memory in Westminster Abbey; and there, in May 1895, a portrait medallion, by Albert Bruce Joy, was placed near the grave of Newton, and adjoining the memorials of Darwin and of Joule. His bust, by the same sculptor, stands opposite that of Herschel in the hall of St John's College, Cambridge, of which both were fellows. Herkomer's portrait is in Pembroke College; and Mogford's, painted in 1851, is in the combination room of St John's. Another bust, taken in his youth, belongs to the Royal Astronomical Society. A memorial tablet, with an inscription by Archbishop Benson, is placed in the Cathedral at Truro; and Mr Passmore Edwards erected a public institute in his honour at Launceston, near his birthplace.

The Scientific Papers of John Couch Adams, 4to, vol. i. (1896), and vol. ii. (1900), edited by William Grylls Adams and Ralph Allen Sampson, with a memoir by Dr J. W. L. Glaisher, and his *Lectures on the Lunar Theory*, edited by Professor Sampson, have been published by the Cambridge University Press. (D. M.*)

Adana, (1) a Turkish vilâyet in the S.E. of Asia Minor, which includes the ancient Cilicia. The mountain districts are rich in mineral wealth, and the fertile coast-plain is well watered by the rivers that descend from the Taurus range. Imports and exports pass through Mersina. Pop. 405,000 (Moslems, 158,000; Ansarieh, &c., 73,000; Christians, 174,000). (2) The chief town of the vilâyet, situated in the alluvial plain on the right bank of the Sihûn, *Sarus*, which is navigable for small craft to its mouth. It is connected with Tarsus and Mersina by a railway built in 1887, and has good buildings, river-side quays, cotton-mills, and an American mission with church and schools. Adana, which retains its ancient name, rose to importance as a station on the Roman military road to the east, and was at one time a rival of Tarsus. During the Middle Ages it often changed hands and suffered many vicissitudes. It is the seat of a British vice-consul. Population, 31,000 (Moslems, 14,000; Christians and Ansarieh, 17,000).

Addigrat. See ABYSSINIA.

Addis-abbaba. See ABYSSINIA.

Adelaide, the capital of South Australia, 7 miles from the mouth of the Torrens river, in 34° 57' S. lat. and 138° 38' E. long. Built on a broad plain running between a range of mountains and the gulf of St Vincent, it is connected by rail with the sea at several points besides Port Adelaide—7½ miles away, including Largs Bay, where the great ocean liners anchor. It is also the terminus of an extensive railway system, of which the main line runs through Melbourne, Sydney, and Brisbane to Rockhampton. Of late years the population, and more especially that of the outlying suburbs, has rapidly increased. The city generally contained in 1901 38,981 inhabitants; the city and suburbs within a 10-mile radius, 162,094. The principal suburbs are Burnside, 7763; Glenelg (like Semaphore, a resort on the coast of the gulf), 3946; Hindmarsh, 9984; Kensington and Norwood, 12,562; Port Adelaide, 20,062; St Peter's, 7605; Thebarton, 5297; and Unley, 18,119. The streets are generally broad, well kept, and well drained; horse tramcars run through the principal thoroughfares; and arrangements have been made with a private company to light certain parts of the city with electricity. A university was established in 1874, and receives a Government grant of £3200 per annum. It has also been magnificently endowed by Sir Thomas Elder, a former citizen, who presented £30,000 for a medical school, £20,000 for arts and science faculties, £20,000 for a chair of music, and £25,000 for the general funds of the university. Other educational institutions include a technical college with over 300 scholars, and a school of mines and industries with over 800. There are extensive Government buildings and law courts, a fine museum and free library, an institute containing a library, an art gallery containing several splendid specimens of modern art, a town hall, a stock exchange, two handsome markets—one the property of the corporation, a hospital, two theatres, an academy of music, city baths, two lunatic asylums, and several charitable institutions. The general post office also deserves special mention, being one of the finest in Australasia. The large hall of the exhibition building is largely used for the purpose of entertainments. Among the monuments are one to Colonel Light, the founder of the colony, statues of Queen Victoria and Robert Burns, and copies of the Farnese Hercules and Canova's Venus. The city is surrounded by park lands, and also contains botanic gardens and a fine collection of zoological specimens. Near Glenelg stands Morpethville racecourse. The thermometer in summer frequently stands as high as 110° F. in the shade, hot winds blowing the while from the interior, but during the rest of the year the climate is mild and pleasant. During a period of about thirty years the mean annual rainfall has been 20·4 inches.

The Adelaide city government is regarded as more progressive than that of any other Australian capital. The municipal council consists of a mayor and six aldermen, elected by the whole body of ratepayers, and twelve councillors elected by six wards. In no other Australian city is the mayor elected by the ratepayers generally. The drainage is managed on a carefully-planned system. For the water-supply there are three storage reservoirs, with a capacity of about 3,550,000,000 gallons of water, and several service reservoirs. The telephone system is owned by the state. South Adelaide is the principal business part of the city, which is the central share-market in Australia for the West Australian gold-fields, and also for the silver-mines of Broken Hill, and the copper-mines of Wallaroo, Burra Burra, and Moonta in South Australia. Viewed from the standpoint of trade Port Adelaide is the third port of Australia. In 1900 the imports were valued at £4,739,483, and the exports at £4,363,971. This suburb is also an important manufacturing centre. Altogether four daily newspapers are issued in Adelaide. (J. D. F.)

Adelsberg (Slovene, *Postojna*), a market town in the Austrian duchy of Carniola, chief town of the district of the same name. Population of commune (1890), 3597, of whom 140 were German and the remainder Slovenes; (1900), 3636. The total length of the passages in the celebrated stalactite cavern, about a mile from the town, is now over 5½ miles. The connexion with the Ottokar Grotto was established in 1890. The Magdalene Grotto, about an hour's walk to the north, is celebrated for the extraordinary subterranean amphibian, the *proteus anguinus*, first discovered there. It is about a foot in length, lives on snails and worms, and is provided with both lungs and gills.

Aden, a seaport and territory in Arabia, politically part of British India, under the governor of Bombay. The seaport is situated in 12° 45' N. lat. and 45° 4' E. long., on a peninsula near the entrance to the Red Sea. It was first occupied by the British in January 1839. From time to time additional land on the mainland has been acquired by cession or purchase, and the adjoining island of Perim, lying in the actual mouth of the strait, was permanently occupied in 1857. Further inland, and along the coast, most of the Arab chiefs are under the political control of the British Government, which pays them regular allowances. The area of the peninsula is only 15 square miles, but the total area of British territory is returned at 80 square miles, including Perim (5 square miles). In 1891 the population was 44,079, of whom no less than 30,914 were males. In 1901 the population was 41,222, showing a decrease of 6 per cent. The average density is 515 persons per square mile. The gross revenue in 1897-98 was Rs.38,07,539, and the municipal income Rs.1,93,922. There are 42 schools, with 1949 pupils, being 5·6 per cent. of the population. There are three printing presses, of which one is in the jail, and the other two belong to a European and a Parsi firm of merchants. In 1900 Aden suffered from an epidemic outbreak of plague.

Aden is strongly fortified, with a permanent garrison of one British and one native regiment, two batteries of artillery, and one company of engineers. The administration is conducted by a political resident, who is also the military commandant. All food requires to be imported, and the water-supply is largely derived from condensation. A little water is obtained from wells, and some from an aqueduct 7 miles long, constructed in 1867 at a cost of £30,000, besides an irregular supply from the old reservoirs. The importance of Aden as a port of call for steamers and a coaling station has grown immensely since the opening of the Suez Canal. It also conducts a considerable trade with the interior of Arabia, and with the Somali coast of Africa on the opposite side of the Red Sea. The submarine cables of the Eastern Telegraph Company here diverge—on the one hand to India, the Far East, and Australia, and on the other hand to Zanzibar and the Cape. The number of steamers visiting the port rose from 535 in 1871-72 to 1214 in 1881-82. In 1897-98 the total number of merchant vessels that entered and cleared was 2496, of which 1080 with a tonnage of 2,124,043 were steamers. The number that called to discharge or take cargo was 816. In addition, 129 British and foreign men-of-war and troopships called at the port. In 1897-98, the total volume of trade amounted, in tens of rupees, to 8,188,393, which is classified into foreign, Indian, and inland. Of the foreign, the imports amounted to Rx. 2,851,193, and the exports to Rx. 3,345,028. Of the Indian, the imports were Rx. 1,250,054, and the exports Rx. 258,800. Of the inland, the imports were Rx. 337,640, and the exports Rx. 145,678. The principal articles of import are coffee, cotton-piece goods, &c., grain, hides, coal, opium, cotton-twist and yarn. The exports are, in the main, a repetition of the imports. Of the total imports, nearly one-third come from the east coast of Africa, and another third from Arabia. Of the total exports, nearly one-third again go to the east coast of Africa. In 1897-98 the share of the United Kingdom was only 13 per cent. of the total imports, and 6 per cent. of the total exports. In that year the receipts of the port trust amounted to Rs.2,48,975, and the expenditure to Rs.2,70,511. The number of vessels that called at Perim was 556, of which 396 were British.

(J. S. Co.)

Adernò, a town of Italy, Sicily, prov. Catania, situated at the S.W. foot of Mount Etna, 22 miles N.W. from Catania by the circum-Etna railway. It has a square Norman tower (now converted into a prison) and a monastery (1157), both built by the Norman count Roger of Sicily; some slight remains survive of the ancient Sikelian city of *Hadranum*, and of its famous temple to Hadranus. Adernò is famous for its oranges, and has flour-mills. Population (1871), 14,613; (1881), 19,180; (1901), 25,873.

Adiquala. See Eritrea.

Adirondacks, a group of mountains in north-eastern New York, U.S.A., a portion of the Appalachian system of eastern North America, occupying the eastern part of the region between Lake Champlain and Lake Ontario, north of the Mohawk Valley. They do not form a connected range, but consist of many summits, isolated or in groups, arranged with little appearance of system. The highest peak, Mount Marcy, altitude 5344 feet, is near the eastern part of the group, and about it are many summits exceeding 4000 in height. These mountains, consisting mainly of somewhat homogeneous granite rocks, are the result of long-continued erosion, carried on in a greatly elevated region, by which the softer areas have suffered the most and the harder the least. In recent geologic times this area, with the exception of the higher summits, was covered by the Laurentian glacier, whose erosion, while perhaps having little effect on the larger features of the country, has greatly modified it in details, producing many lakes and ponds, together with rapids and falls in the streams. The region is heavily forested with spruce, pine, and broad-leaved trees, forming the only continuous forest area remaining in the state. In order to preserve these forests from destruction the state withholds its lands from sale, and as opportunity offers, increases its holdings by purchase. In 1900 the area of state lands comprised 1,250,000 acres. The Adirondack region, with its mountains, lakes, and forests, presents much beautiful, and even grand, scenery, and is greatly frequented in summer as a resort and sanatorium.

Adi-Ugri. See Eritrea.

ADMIRALTY ADMINISTRATION.

British Empire.

I. The *Administrative System.*—That the navy is the only real defence of the British islands has been recognized by English people ever since the days of King Offa, who died in 796, leaving to his successors the admirable lesson that "he who would be secure on land must be supreme at sea." The truth of the lesson thus learnt is sanctioned by all the experience of English history, and Parliament has repeatedly enforced the fact. The navy is the only force that can safeguard the British islands from hostile descents; it is the only force that can protect their vast sea-borne commerce and food supplies; by giving safety to the home country it sets British troops free for operations abroad, and makes their passage secure; and thus, as also by giving command of the sea, the fleet is the means by which the empire is guarded and has become a true imperial bond.

British naval administration is conducted by the Board of Admiralty, and the function of that board is the maintenance and expansion of the fleet in accordance with the policy of the Government, and the supplying of it with trained officers and men; its distribution throughout the world; and its preservation in readiness and efficiency in all material and personal respects. The character of the Admiralty Board is peculiar to the British constitution, and it possesses certain features which distinguish it from other departments of the State. The business it conducts is very great and complex, and the machinery by which its work is done has grown with the expansion of that business. The whole system of naval administration has been developed historically, and is not the product of the organizing skill of one or a few individuals, but an organic growth possessing marked and special characteristics. The Admiralty Board derives its character from the fact that it represents the Lord High Admiral, and that its powers and operation depend much more upon usage than upon

The Board of Admiralty.

those instruments which actually give it authority, and which, it may be remarked, are not in harmony among themselves. The executive operations are conducted by a series of civil departments which have undergone many changes before reaching their present constitution and relation to the Board. The salient characteristic of the Admiralty is a certain flexibility and elasticity with which it works. Its members are not, in a rigid sense, heads of departments. Subject to the necessary and constitutional supremacy of the Cabinet Minister at their head, they are jointly and co-equally "commissioners for executing the office of High Admiral of the United Kingdom, and of the territories thereunto belonging, and of High Admiral of the colonies and other dominions." The members of the Board are in direct and constant communication with the First Lord and with one another, as also with the civil departments which work under their control. It was enjoined by James I. that the principal officers and commissioners of the navy should be in constant communication among themselves, consulting and advising "by common council and argument of most voices," and should live as near together as could conveniently be, and should meet at the navy office at least twice a week. This system of intercommunication still exists in a manner which no system of minutes could give; and it may be remarked, as illustrative of the flexibility of the system, that a Board may be formed on any emergency by two Lords and a secretary, and a decision arrived at then and there. Such an emergency Board was actually constituted some years ago on board the Admiralty yacht in order to deal on the instant with an event which had just occurred in the fleet. At the same time it must be remarked that, in practice, the First Lord being personally responsible under the Orders in Council, the operations of the Board are dependent upon his direction.

History.

The present system of administering the navy dates from the time of Henry VIII. The naval business of the country had so greatly expanded in his reign that we find the Admiralty and Navy Board reorganized or established; and it is worthy of remark that there existed at the time an Ordnance branch, the navy not yet being dependent in that matter upon the War Department.[1] The Navy Board administered the civil departments under the Admiralty, the directive and executive duties of the Lord High Admiral remaining with the Admiralty office. A little later the civil administration was vested in a Board of principal officers subordinate to the Lord High Admiral, and we can henceforth trace the work of civil administration being conducted under the navy and victualling boards apart from, but yet subject to, the Admiralty itself. This was a system which continued during the time of all the great wars, and was not abolished until 1832, when Sir James Graham, by his reforms, put an end to what appeared a divided control. Whatever may have been the demerits of that system, it sufficed to maintain the navy in the time of its greatest achievements, and through all the wars which were waged with the Spaniards, the Dutch, and the French. The original authority for the present constitution of the Admiralty Board is found in a declaratory Act of the 2 William and Mary, c. 2, in which it is enacted that "all and singular authorities, jurisdictions, and powers which, by Act of Parliament or otherwise, had been lawfully vested" in the Lord High Admiral of England had always appertained, and did and should appertain to the commissioners for executing the office for the time being "to all intents and purposes as if the said commissioners were Lord High Admiral of England." The Admiralty commission was dissolved in 1701, and reconstituted on the death of Prince George of Denmark, Lord High Admiral in 1709. From that time forward, save for a short period in 1827-28, when the Duke of Clarence was Lord High Admiral, the office has remained in commission.

It is unnecessary to describe in detail the many changes which have passed over the system of naval administration up to the present time. When Lord St Vincent accepted office under the Addington ministry in 1801, it fell to him to deal with a vast system of waste, extravagance, and malversation of public funds. The work of reform was too vast even for this strong administrator to accomplish, and the great seaman became the object of a torrent of virulent abuse embodied in an extraordinary pamphlet literature. When the Addington ministry fell he left office, but the work he had done bore good fruit later. The investigations which were conducted at that time were essentially the basis of the reorganization effected by Sir James Graham under the administration of Earl Grey. That reorganization involved the abolition of the Board of principal officers and commissioners of the navy, and the commissioners for victualling, the whole business of naval administration being concentrated under the immediate direction of the Board of Admiralty. The "Act to amend the laws relating to the business of the civil departments of the navy, and to make other regulations for more effectually carrying on the duties of the said departments" (2 William IV. c. 40), vested in the Admiralty Board all the powers of the commissioners of the civil departments, and provided for the creation of five separate and independent responsible superintendents of departments under the Admiralty collectively, and the several Lords individually. These new officers were the surveyor of the navy, the accountant-general, the storekeeper-general, the controller of victualling and transports, and the physician of the navy, whose title in 1843 became director-general of the medical department of the navy. A number of changes have since been made, but the general principle remains the same, and the constitution of the Admiralty Board and civil departments is described below. The Board consisted of the First Lord and four Naval Lords with a Civil Lord, who were accustomed to meet sometimes daily, but at all times frequently; and the system developed provided for the sub-division of labour, and yet for the co-ordinated exertion of effort.

A fresh system, at variance with Admiralty tradition and practice, was introduced by Mr Childers in 1869. But those changes have now almost entirely been reversed. The system of intercommunication in the Board was paralysed by an attempt to lay down definite rules of practice and to define what was essentially indefinable. When Mr Goschen succeeded Mr Childers he found it necessary to modify the system; and since that time it may be said that the Admiralty Board has resumed, broadly, the character which it had after the reorganization of Sir James Graham. The merits of that system, as conducing to elasticity and flexibility of working, have been pointed out; and, whatever its disadvantages, it is not to be denied that the system has worked well in practice, and has certainly won the approval and the admiration of many statesmen.[2] Lord George Hamilton said, before the Royal Commission on civil establishments, 1887, that "It has this advantage, that you have all departments represented round a table, and that if it is necessary to take quick action, you can do in a few minutes that which it would take hours under another system to do"; and the report of the Royal Commission of 1889 remarked that "The constitution of the Board of Admiralty appears to us well designed, and to be placed under present regulations on a satisfactory footing."

---

[1] The Board of Ordnance was originally instituted for the navy, but eventually fell into military hands, to the detriment of the navy—the only navy of any nation that has not full authority over its own ordnance. In 1653, according to Oppenheim, it was, owing to its inefficiency, placed under the Admiralty. In 1632 it appears to have been independent, but "still retained that evil pre-eminence in sloth and incapacity it had already earned and has never since lost."

[2] The Duke of Somerset, Lord Halifax, Sir J. Graham, Sir F. Baring, and others stated that "the administrative system contrasted most favourably with any department they had been connected with," as did the more recent commission under Lord Hartington's presidency.

Powers.

The special characteristics of the Admiralty Board which have been described are accompanied by a very peculiar and noteworthy feature, which is not without relation to the untrammelled and undefined operations of the Admiralty. This feature arises from the discrepancy between the Admiralty patent and the Orders in Council, for the Admiralty is not administered according to the terms of the patent which invests it with authority, and its operations raise a singular point in constitutional law.

The legal origin of the powers exercised by the First Lord and the Board itself is indeed curiously obscure. Under the patent the full power and authority are conferred upon "any two or more" of the commissioners, though, in the patent of Queen Anne, the grant was to "any three or more of you." It was under the Act 2 Will. IV. c. 40 that two Lords received the necessary authority to legalize any action of the Board; but already, under an Act of 3 George IV., two Lords had been empowered to sign so long as the Board consisted of six members. We therefore find that the legal authority of the Board under the patent is vested in the Board; but in the Order in Council of 14th January 1869 the sole responsibility of the First Lord was officially laid down, and in the Order in Council of 19th March 1872 the First Lord was made "responsible to your Majesty and to Parliament for all the business of the Admiralty." As a matter of fact, the authority of the First Lord, independent of his colleagues, had existed in an undefined manner from ancient times. Before a select committee of the House of Commons in 1861 the Duke of Somerset stated that he considered the First Lord responsible, that he had always "acted under that impression," and that he believed "all former First Lords were of this opinion"; while Sir James Graham said that "the Board of Admiralty could never work, whatever the patent might be, unless the First Lord were supreme, and did exercise constantly supreme and controlling authority." It is not, therefore, surprising to find that there has been undoubtedly direct government without a Board. Thus, in the operations conducted against the French channel ports in 1803-4, Lord Melville, then First Lord, took steps of great importance without the knowledge of his colleagues, though he afterwards bowed to their views, which did not coincide with his own. Again, when Lord Gambier was sent to Copenhagen in 1807, he was instructed to obey all orders from the King, through the principal Secretary of State for war, and in this way received orders to attack Copenhagen, which were unknown to all but the First Lord. In a similar way the secretary of the Admiralty was despatched to Paris in 1815 with instructions to issue orders as if from the Board of Admiralty when directed to do so by the foreign secretary who accompanied him, and these orders resulted in Napoleon's capture. These instances were cited, except the first of them, by Sir James Graham before the select committee of the House of Commons in 1861, in order to illustrate the elastic powers under the patent which enabled the First Lord to take immediate action in matters that concerned the public safety. It is not surprising that this peculiar feature of Admiralty administration should have attracted adverse criticism, and have led some minds to regard the Board as "a fiction not worth keeping up"—a view expressed by Mr Baxter, parliamentary secretary in 1871. There have been instances of the power of the First Lord being misused, and in relation to the loss of the *Captain* in 1870, it seemed a legitimate conclusion to draw from the evidence before the House of Lords committee that Mr Childers, being himself nominally responsible for sending this vessel to sea, constituted himself a judge of the case, and, exempting himself from blame, distributed censure among a number of persons, while he placed the chief weight on the Controller, who had been by a former board specially released from this responsibility.[1] The truth is that there existed antecedently to the Admiralty patents, and now concurrently exists with them, an undefined power based upon usage enabling the First Lord to act independently of his colleagues. This is a feature of administration that evidently springs from necessity and political expediency.

The case of the *Captain* had a beneficial effect upon Admiralty administration. It caused the Board to be reinstated in its former position, and gave once more to the system those advantages of intercommunication and consultation which have been alluded to. It cannot be said, however, that the question of ultimate responsibility is well defined. The Duke of Somerset, Sir James Graham, and Sir Charles Wood, afterwards Lord Halifax, held the view that the First Lord was singly and personally responsible for the sufficiency of the fleet. Sir Arthur Hood expressed before the House of Commons committee in 1888 the view that the Board collectively were responsible; whilst Sir Anthony Hoskins assigned the responsibility to the First Lord alone with certain qualifications, which is a just and reasonable view.

II. *Admiralty Organization.*—Under the organization which now exists, the Board of Admiralty consists of the First Lord, the first and second Naval Lords, the Additional Naval Lord and Controller, the junior Naval Lord, and the Civil Lord, who are commissioners for executing the office of Lord High Admiral, and with them are the parliamentary and financial secretary and the permanent secretary. As has been explained, the First Lord is responsible under the Orders in Council to the Crown and to Parliament for all Admiralty business. In the hands of the other Lords and secretaries rest duties very carefully defined, and they direct the civil departments which are the machinery of naval administration. The first Naval Lord, the second Naval Lord, and the junior Naval Lord are responsible to the First Lord in relation to so much of the business concerning the personnel of the navy and the movements and condition of the fleet as is confided to them, and the Additional Naval Lord or Controller is responsible in the same way for the material of the navy; while the parliamentary secretary has charge of finance and some other business, and the Civil Lord of all shore works—*i.e.*, docks, buildings, &c.—and the permanent secretary of special duties. The First Lord of the Admiralty is the cabinet minister through whom the navy receives its political direction in accordance with imperial policy. He is the representative of the navy in Parliament, which looks to him for everything concerned with naval affairs. The members of the Board are his advisers; but if their advice is not accepted, they have no remedy except protest or resignation. It cannot be denied that the responsibility of the members of the Board, if their advice should be disregarded, must cease, and it is sufficiently obvious that the remedy of resignation will not always commend itself to those whose position and advancement depend upon the favour of the Government.

---

[1] The late Admiral Sir Cooper Key, when director of naval ordnance during Mr Childers's administration, observed to the writer that no First Lord of the Admiralty knew so little of the working of the Admiralty as Mr Childers, because, owing to the discontinuance of Board meetings, he lost the great advantage of hearing the discussion. (H. V. H.)

Something will be said a little later concerning the working of the system and the relation of the First Lord to the Board in regard to the navy estimates. In addition to general direction and supervision, the First Lord has special charge of promotions and removals from the service, and of matters relating to honours and rewards, as well as the appointments of flag officers, captains, and other officers of the higher ranks. With him rests also the nomination to naval cadetships for the major part and assistant clerkships.

Apart from the First Lord, the first Naval Lord is the most important officer of the Board of Admiralty. It seems to be unquestionable that Sir James Graham was right in describing the senior Naval Lord as his "first naval adviser." Theoretically, the first Naval Lord is responsible for the personnel of the fleet; but in practice he is necessarily concerned with the material also as soon as it is put into commission, and with the actual commissioning of it. It is correct to say that he is chiefly concerned with the employment of the fleet, though his advice has weight in regard to its character and sufficiency, and is always sought in relation to the shipbuilding programme. Broadly speaking, the first Naval Lord's duties and authority cover the fighting efficiency and employment of the fleet, and upon him and upon the Controller the naval business of the country largely falls. He directs the operations of the admiral superintendent of naval reserves in regard to ships, the hydrographer, the director of naval ordnance, so far as the gunnery and torpedo training establishments are concerned, and the naval intelligence department, and he has charge of all matters relating to discipline. The mobilization of the fleet, both in regard to personnel and material, also falls to him, and among a mass of other business in his department are necessary preparations for the protection of trade and the fisheries. It will thus be seen that the first Naval Lord is the chief officer of the Board of Admiralty, and that the operations of the other members of the Board all have relation to his work, which is no other than preparation for war. It may here be remarked that it appears most necessary to change the Naval Lords frequently, so that there may always be in the Board some one who possesses recent touch with the service afloat.

The second Naval Lord may be regarded as the coadjutor of the first Naval Lord, with whose operations his duties are very closely related, though, like every other member of the Board, he is subordinate only to the First Lord. The duties of the second Naval Lord are wholly concerned with the personnel of the fleet, the manning of the navy, and mobilization. In his hands rests the direction of naval education, training, and the affairs of the royal marine forces. The training establishments and colleges are in his hands. He appoints navigating officers and lieutenants to ships (unless they be to command), sub-lieutenants, midshipmen, and cadets, engineer officers, gunners, and boatswains, and supervises the management of the reserve. In his province is the mobilization of the personnel, including the coastguard and the royal naval reserve. Necessarily, the first and second Naval Lords work together, and upon occasion can replace each other. It was explained to the House of Lords committee in 1871—and the condition still prevails—that the two senior Naval Lords—at that time Admiral Sir Frederick Grey and Vice-Admiral Eden—were in constant communication in relation to the complements of ships and the manning of the fleet, and that each knew intimately the other's work, and when necessary could take charge of it with perfect confidence.[1]

Most important are the duties that fall to the Additional Naval Lord and Controller. He has charge of everything that concerns the material of the fleet, and his operations are the complement of the work of the first Naval Lord. A great number of civil departments are directed by the Controller, and his survey and supervision extend to the dockyards and building establishments of the fleet. He submits plans to the board for new ships, and is responsible for carrying into effect its decisions in regard to all matters of construction and equipment. The building operations both in the dockyards and in private yards are therefore under his supervision. In regard to all these matters, the director of naval construction and the engineer-in-chief are the heads of the civil departments that carry on the work. Again, the controller is responsible in regard to armament—both gunnery and torpedo—and it is the work of his department to see to all gunnery and torpedo fittings, and to magazines, shell-rooms, and electric apparatus. The officer in immediate charge of this branch of the Controller's work, under his direction, is the director of naval ordnance. In regard to work at the dockyards (*q.v.*) the Controller is aided by the director of dockyards. He supervises this officer in preparing the programme of work done in the dockyards, the provision of the material required, and its appropriation to particular work in accordance with the programme. Other officers who conduct great operations under the authority and responsibility of the Controller are the director of stores, who maintains all necessary supplies of coal and stores at home and abroad, and examines the store accounts of ships, and the inspector of dockyard expense accounts, who has charge of the accounts of dockyard expenditure and seeing that outlay is charged as directed. In regard to the navy estimates, the Controller, through his subordinates, is responsible for the preparation and administration of votes 8 and 9 (those for shipbuilding and naval armaments), except in regard to some subheadings of the former, and thus in the year 1900-1 for the expenditure of something like £15,000,000.

The junior Naval Lord has in his hands the very important duties that are concerned with the transport, medical, and victualling services, as well as the regulation of hospitals, the charge of coaling arrangements for the fleet, and other duties that conduce to the practical efficiency of the navy. He also appoints chaplains, naval instructors, medical officers (except in special cases), and officers of the accountant branch. A vast business in regard to the internal economy of ships greatly occupies the junior Lord. He has charge, for example, of uniforms, prize-money, bounties, naval savings banks, and pensions to seamen and marines, and the widows of naval and marine officers. The work of the junior Naval Lord places under his direction the director of transports, the director-general of the Medical Department, the director of victualling, and, in regard to particular matters, the director of stores, the accountant-general, the chaplain of the fleet, and the Intelligence Department, so far as the junior Lord's department is concerned.

The Civil Lord supervises, through the director of works, the Works Department, dealing with Admiralty buildings and works, construction and labour, contracts, and purchases of building stores and land. He is also responsible for the civil staff of the naval establishments, except in regard to certain officials, and for duties connected with Greenwich Hospital, compassionate allowances, charitable funds, and business of like character. The accountant-general, in regard to these matters, is directed by him, and the director of Greenwich Hospital is under his authority.

The parliamentary and financial secretary is responsible for the finance of the department, the navy estimates, and matters of expenditure generally, and is consulted in regard to all matters involving reference to the Treasury.

---

[1] The drawback is, that a Naval Lord can only go on leave by throwing all his work on a colleague already overweighted with work.

His position in regard to estimates and expenditure is very important, and the accountant-general is his officer, while he has financial control over the director of contracts. The financial secretary also examines proposals for new expenditure.

A most important official of the Board is the permanent secretary, whose office has been described as the "nerve-centre" of the Admiralty, since it is the channel through which papers for the Lords of the Admiralty pass for the inter-communication of departments and for the correspondence of the Board. The tradition of Admiralty procedure largely rests with the permanent secretary, and it is most important that he should be chosen from one of the branches, and should have served in as many of them as possible, in order that he may possess a thorough knowledge of the theory and practice of the Admiralty system. In addition to the secretarial duties of the permanent secretary's department, the permanent secretary has charge of the military, naval, and legal branches, each under a principal clerk, the civil branch, and the record office. The various branches deal with matters concerning the commissioning of ships and the distribution of the fleet, and the manning and discipline of the navy, with other associated matters, being the channels for the operations of the Naval Lords. It is a highly important function of the department of the permanent secretary to preserve the inter-related working of the various departments, and to keep unbroken the thread of administration when a new Board is constituted.

The following is a list of the First Lords and first Naval Lords since 1832:—

First Lords.	*Senior Naval Lords.*
Sir James R. G. Graham, Bart., November 1830.	Rear-Adm. Sir Thomas M. Hardy.
Lord Auckland, June 1834.	(1) Rear-Adm. Sir Thomas M. Hardy. (2) Rear-Adm. the Hon. George H. L. Dundas. (3) Rear-Adm. Sir Charles Adam.
Earl de Grey, December 1834.	Vice-Adm. Sir John P. Beresford, K.C.B.
Lord Auckland, April 1835.	Rear-Adm. Sir Charles Adam.
The Earl of Minto, G.C.B., September 1835.	Rear-Adm. Sir Charles Adam.
The Earl of Haddington, September 1841.	Adm. Sir George Cockborn, G.C.B.
The Earl of Ellenborough, January 1846.	Adm. Sir George Cockburn, G.C.B.
The Earl of Auckland, July 1846.	(1) Vice-Adm. Sir Charles Adam, K.C.B. (2) Rear-Adm. James W. D. Dundas, C.B.
Sir Francis Thornhill Baring, Bart., January 1849.	(1) Rear-Adm. James W. D. Dundas, C.B. (2) Rear-Adm. the Hon. M. Fitzhardinge Berkeley, C.B.
The Duke of Northumberland, K.G., February 1852.	Rear-Adm. Hyde Parker, C.B.
Sir James R. G. Graham, Bart., January 1853.	(1) Vice-Adm. Hyde Parker, C.B. (2) Rear-Adm. the Hon. M. Fitzhardinge Berkeley, C.B.
Sir Charles Wood, March 1855.	(1) Rear-Adm. the Hon. M Fitzhardinge Berkeley, C.B. (2) Rear-Adm. the Hon. Sir Richard S. Dundas, K.C.B.
Sir John Pakington, Bart., March 1858.	Vice-Adm. William Fanshawe Martin.
The Duke of Somerset, June 1859.	(1) Vice-Adm. the Hon. Sir Richard S. Dundas, K.C.B. (2) Rear-Adm. the Hon. Sir Frederick W. Grey, K.C.B.
Sir John S. Pakington, Bart., G.C.B., July 1866.	Vice-Adm. Sir Alexander Milne, K.C.B.
Rt. Hon. Henry Thomas Lowry Corry, March 1867.	Vice-Adm. Sir Alexander Milne, K.C.B.
Rt. Hon. Hugh Culling Eardley Childers, December 1868.	Vice-Adm. Sir Sydney C. Dacres, K.C.B.
Rt. Hon. George J. Goschen, March 1871.	(1) Vice-Adm. Sir Sydney C. Dacres, K.C.B. (2) Adm. Sir Alexander Milne, G.C.B.
Rt. Hon. George Ward Hunt, March 1874.	(1) Adm. Sir Alexander Milne, G.C.B. (2) Adm. Sir Hastings R. Yelverton, G.C.B.
Rt. Hon. William Henry Smith, August 1877.	(1) Adm. George G. Wellesley, C.B. (2) Adm. Sir Astley Cooper Key, K.C.B.
The Earl of Northbrook, May 1880.	Adm. Sir Astley Cooper Key, K.C.B.
Lord George Hamilton, July 1885.	Vice-Adm. Arthur W. Acland Hood, C.B.
The Marquis of Ripon, K.G., February 1886.	Adm. Lord John Hay, K.C.B.
Lord George Hamilton, August 1886.	(1) Adm. Sir Arthur W. Acland Hood, K.C.B. (2) Adm. Sir R. Vesey Hamilton, K.C.B. (3) Adm. Sir Anthony H. Hoskins, K.C.B.
Earl Spencer, K.G., August 1892.	(1) Adm. Sir Anthony H. Hoskins, K.C.B. (2) Adm. Sir Frederick W. Richards, K.C.B.
Rt. Hon. George J. Goschen, July 1895.	(1) Adm. Sir Frederick W. Richards, K.C.B. (2) Vice-Adm. Lord Walter Kerr, K.C.B.
The Earl of Selborne, November 1900.	Adm. Lord Walter Kerr, K.C.B.

III. *Business and Responsibility.*—The manner in which the Admiralty Board conducts the great operations under its charge has been indicated. It would be impossible here to describe it in detail, though something concerning the civil departments, which are the machinery of naval administration, will be found below. It will, however, indicate the character of Admiralty administration if we explain to some extent the conditions which surround the preparation of the estimates and the shipbuilding programme, the more so because this matter has been the battle-ground of critics and supporters of the Admiralty. It has already been pointed out that the Naval Lords, if they dissent from the estimates that are presented, have no remedy but that of protest or resignation. Into the controversies that have arisen as to the responsibility of the several Lords it is unnecessary to enter here. The Admiralty Board possesses, in fact, the character of a council, and its members can only be held responsible for their advice. It has even been contended that, in the circumstances, it should not be incumbent upon them to sign the navy estimates, and there have been instances in which the estimates have been presented to Parliament without the signature of certain Naval Lords. It is in any case obvious, as has been explained above, that the ultimate responsibility must always rest with the First Lord and the Cabinet, by whom the policy of the country is shaped and directed. In the report of the Hartington Commission to inquire into the civil and professional administration of the Naval and Military Departments, and the relation of these departments to each other and to the Treasury, the following recommendation occurs: "On the First Lord alone should rest the responsibility of deciding on the provision to be made for the naval requirements of the empire, and the existence of a council should be held in no degree to diminish that responsibility."

Two conditions primarily rule the determination as to the strength of the navy. They are, the foreign policy of the Cabinet, and, on the ground of practical expediency, the amount of money available. "The estimates and strength of the navy," said Rear-Admiral Hotham before the select committee on the navy estimates, 1888, "are matters for the Cabinet to determine." "Expense," said Sir Anthony Hoskins, "governs everything." The needs of the empire and financial considerations, as it is scarcely necessary to remark, may prove to be antithetical conditions governing the same problem, and in practice it follows that the Admiralty Board directs its operations in accordance with the views of the Government, but limited by the public funds which are known to be available. Such considerations suggest a practical limitation of responsibility, so far as the several Lords of the Admiralty are concerned, but it may be presumed to be their duty individually or collectively to place their views before the First Lord; and Lord George Hamilton told the select committee of 1888 that, if his colleagues should represent to him that a certain expenditure was indispensable for the efficiency of the service, he would recognize that all financial considerations should be put on one side. The commissioners reported that this was the only common-sense view of the matter, and that it was difficult to see on what other footing the control of navy expenditure, consistently with responsibility to Parliament, could be placed.

Two practical considerations are bound up with the shipbuilding programme—the carrying forward of the work in hand and the new construction to be begun, since it is absolutely necessary that proper provision should be made for the employment and distribution of labour in the dockyards, and for the purchase of necessary materials. Through the director of naval construction and the director of dockyards, the Controller is kept informed as to the progress of work and the amount of labour required, as also in regard to the building facilities of the yards. These matters, in a general way, must form a subject of discussion between the first Naval Lord and the Controller, who will report on the subject to the First Lord. The accountant-general, as the financial officer of the Board, will be called upon to place the proposed estimates upon a financial basis, and when the views of the Cabinet are known as to the amount of money available, the several departments charged with the duty of preparing the various votes will proceed with that work. The financial basis alluded to is, of course, found in the estimates of the previous year, modified by the new conditions that arise. There has been in past times a haphazard character in our shipbuilding programmes, but with the introduction of the Naval Defence Act of 1889, which looked ahead and was not content with hand-to-mouth provision, a better state of things has grown up, and, with a larger sense of responsibility, a policy characterized by something of continuity has been developed. Certainly the largest factor in the better state of things has been the growth of a strong body of public opinion as to the supreme value of the navy for national and imperial welfare. No Government could have carried forward the great work which has been accomplished for the British navy within the last ten years without the impulsion and the support of public opinion.

Another important and related matter that comes before the Board of Admiralty is the character and design of ships. The naval members of the Board indicate the classes and qualities desired, and it is the practice that the sketch-design, presented in accordance with the instructions, is fully discussed by the first Naval Lord and the Controller and afterwards by the Board. The design then takes further shape, and when it has received the final sanction of the Board it cannot be altered without the sanction of the same authority. A similar procedure is found in the other business of the Admiralty Board, such as shore-works, docks, and the preparation of offensive and defensive plans of warfare—the last being a very important matter that falls into the operations of the Naval Intelligence Department, which has been described, though not with perfect accuracy, and certainly in no large sense, as "the brain of the navy." That department is under the direction of the first Naval Lord.

The shipbuilding programme may be described as the corner-stone of the executive business of the Admiralty, because upon it depends very largely the preparation of all the other votes relating to numbers, stores, victualling, clothing, &c. But if the Admiralty Board is responsible through the First Lord for the preparation of the estimates, it is also charged with the business of supervising expenditure. In this matter the financial secretary plays a large part, and is directed to assist the spending department of the Admiralty in their duty of watching the progress of their liabilities and disbursements. Some notes on Admiralty finance will be found below (parts iv., vii.). The shipbuilding votes set the larger machinery of the Admiralty in motion. The executive departments, except in regard to the hulls and machinery of ships and the special requirements of the director of works, do not make purchases of stores, that work resting with the director of navy contracts. Most of the important executive and spending branches are in the department of the Controller, and it will be well, while we are dealing with the material side of the navy, to describe briefly their character and duties. The civil branches of the navy tributary to the Controller are those of the director of naval construction, the engineer-in-chief, the directors of naval ordnance, of dockyards, and of stores, and the inspector of dockyard expense accounts. The first duty of the Controller is, as has been explained, in relation to the design and construction of ships and their machinery, and the executive officials who have charge of that work are the director of naval construction and the engineer-in-chief, whose operations are closely inter-related. A vast administrative stride has been made in this particular branch of the Admiralty. The work of design and construction now go forward together, and the Admiralty designers are in close touch with the work in hand at the dockyards—a condition which did not exist twenty-five years ago. This has been largely brought about by the institution, in 1883, of the royal corps of naval constructors, whose members interchange their duties between the designing of ships at the Admiralty and practical work at the dockyards. It is through the director of naval construction that many of the spending departments are set in motion, since he is responsible both for the design of ships and for their construction. It deserves to be noticed, however, that a certain obscurity exists in regard to the relative duties of the director of naval construction and the director of dockyards touching constructive works in the yards. The former officer has also charge of all the work given out to contract, though it is the business of the dockyard officials to certify that the conditions of the contract have been fulfilled. In all this work the director of naval construction collaborates with the engineer-in-chief, who is an independent officer and not a subordinate, and whose procedure in regard to machinery closely resembles that adopted in the matter of contract-built ships.

The director of naval ordnance is another officer of the Controller's Department whose operations are very closely related to the duties of the director of naval construction, and the relation is both intimate and sustained, for in the Ordnance Department everything that relates to guns, gun-mountings, magazines, torpedo apparatus, electrical fittings for guns, and other electrical fittings is centred. A singular feature of this branch of administration is that the navy long since lost direct control of ordnance matters, through the duties connected with naval gunnery, formerly in the hands of the master-general of the ordnance, and those of the Board of Ordnance—a department common to the sea and land services—being vested in 1855 in the Secretary of State for war. A more satisfactory state of things has grown up through the appointment of the director of naval ordnance, taking the place of the naval officer who formerly advised the director of artillery at the War Office. Expenditure on ordnance has also been transferred from the army to the navy estimates, and a Naval Ordnance Store Department has been created. It cannot be said that the condition is yet satisfactory, nor can it be until the navy has control of and responsibility for its own ordnance. The assistant-director of torpedoes is an officer instituted at the Admiralty within recent years, and his duty is to assist the director of naval ordnance in all torpedo matters.

As to the operations of the director of dockyards little need be said here. (See DOCKYARDS.) This officer replaced the surveyor of dockyards in 1885, at about which time the inspector of dockyard expense-accounts was instituted. It is upon the director of dockyards that the responsibility of the Controller devolves in regard to the management of dockyards and naval establishments at home and abroad, and to the performance of work in these establishments, ship and boat building, maintenance, repairs, and refits. In this department the programme for work in the dockyards is prepared, as well as certain sections of the navy estimates.

We now come to the Stores Department, with the director of stores as its chief. This officer, about the year 1869, took over the storekeeping duties previously vested in the storekeeper-general. The Naval Store Department is charged with the custody and issue of naval, as distinguished from victualling and ordnance stores, to be used in naval dockyards and establishments for the building, fitting, and repairing of warships. It has, however, no concern with stores that belong to the Department of Works. The business of the director of stores is also to receive and issue the stores for ships of all classes in commission and reserve, and he deals with a vast array of objects and materials necessary for the fleet, and with coals and coaling. He frames the estimates for his department, but his purchases are made through the director of navy contracts. In practice the main business of the Stores Department is to see to the provision of stores for the navy, and to the proper supply of these at all the establishments, and for this purpose its officials direct the movements of storeships, and arrange for the despatch of colliers, the director being charged to be "careful to provide for His Majesty's ships on foreign stations, and for the necessary supplies to foreign yards." Another important business of the director of stores is the examination of the store accounts of ships as well as some other accounts. Although the director of stores is really in the department of the Controller, he is supervised in regard to the coaling of the fleet by the junior Naval Lord. The inspector of dockyard expense-accounts has been alluded to. He is the officer charged with keeping a record of expenditure at the dockyards and of supervising expense accounts.

IV. *The Matériel of the Navy—Recent Administration.*—Having now described the administrative system of the navy, taking the preparation of the shipbuilding programme as an illustration, it will be well here to recall the recent history of naval administration in that regard. The shipbuilding programme is the beginning of the practical work of administration, because the Government having shaped its policy and indicated its requirements and the possibilities that present themselves, the material elements of naval power are created, and the personal elements, with all that concerns the training of officers and men, follow according to the necessities implied by the existence of that materiel. This is not to say that the ship is more important than the company who are in her, but only that the matériel of the navy constitutes the conditions for which the personnel are embodied, organized, and trained. It will be obvious from what follows, in regard to the shipbuilding programmes of recent years, that the development of the fleet, conducted by the Admiralty under the authority of the First Lord and the Cabinet, has been largely influenced by the voice of public opinion. A Government in power has strong inducement to keep down expenditure and taxation, and the stimulus of a strong body of public opinion appears to be necessary in order to insure that the navy shall be maintained in adequate strength. This is a matter which cannot be overlooked in any account of naval administration. In the spring of 1870 Mr Childers assured Parliament that the navy was efficient for any duty it was likely to be called on to perform—as did Lord Cardwell for the army. In June, when the Franco-German war broke out, £2,000,000 was voted to put the armed forces in a state of efficiency, although the war did not directly affect Great Britain.

At the time of the Russo-Turkish war great uneasiness was manifested in the United Kingdom as to the sufficiency of the navy, and on 25th January 1878 a vote of credit of £6,000,000 was passed by the House of Commons to enable the Admiralty to make good the deficiency.

The Naval Defence Act, 1889.

The existing programme was pushed forward, and a number of ships were bought, but consistent policy was still absent from the proceedings. Again, when the estimates of 1884-85 were presented uneasiness still existed, and Lord Northbrook said in the House of Lords that it would be an extravagance to spend £2,000,000 in the construction of large ironclads, and that the great difficulty the Admiralty would have to contend with, if they were granted £3,000,000 or £4,000,000 for the purpose referred to, would be to decide how they should spend the money. It is true that at the time the minds of naval constructors were not settled as to the type of vessel desirable, and that there were many fluctuations of opinion in regard to naval policy. But at about the same time alarm was spread by the action of Russia upon the Afghan frontier, in relation to what was known as the "Panjdeh incident," and Lord Northbrook introduced a special shipbuilding programme. He explained, in March 1885, that in the navy estimates for the year there would be an increase of £800,000 for building ships by contract and carrying out the programme announced in the previous December. In addition the navy estimates of the year showed the further increase of £700,000, making a total augmentation, exclusive of supplementary estimates, of about £1,500,000. The country had been profoundly moved by the political situation abroad, and from that time may be said to date the great expansion of the fleet which has taken place since the introduction of the Naval Defence Act of 1889. A powerful agitation was conducted by the press, and at length the necessity of a great expenditure was recognized by the Government. In the previous year Lord Charles Beresford, being dissatisfied with the provision made for the navy, had resigned his seat at the Admiralty Board, proposing a programme of additional ships which he considered to be necessary. Many articles were contributed to the press, and a meeting was convened in the City of London by the Lord Mayor, so that pressure was put upon the Government and the Admiralty, and a five years' programme was introduced by Lord George Hamilton, then First Lord. As a ground of decision in regard to the naval strength required, the

Admiralty, after the naval manœuvres of 1888, had directed three admirals—Sir William Dowell, Sir R. Vesey Hamilton, and Sir F. Richards—to furnish a report. They arrived at the following conclusion: "It will not be found practicable to maintain an effective blockade of an enemy's squadrons in strongly fortified ports by keeping the main body of the fleet off the port to be blockaded, without the blockading battleships being in the proportion of at least five to three to allow a sufficient margin for casualties, to which the enemy's vessels in a secure harbour would not be exposed, and the necessary periodical absence of a portion of the blockading squadron for the purpose of replenishing fuel, making good defects, &c. A still larger proportion might be necessary if the area to be covered by the blockaders was extensive." It may be said that this report was at the base of the Naval Defence Act programme and of those which have followed it, and it has constantly been appealed to by writers and speakers, though it is a question whether recent developments of foreign navies do not indicate the necessity of a larger proportion of British ships. The Naval Defence Act, 1889, 52 Vict. cap. 8, being "an Act to make further provision for naval defence and defray the expenses thereof," marked the beginning of a larger conception on the part of the Government and the Admiralty of the needs of the British empire, and it may be said to have formed the practical beginning of the existing efficient navy. Ships were in existence—the *Admiral* class, for example—of an earlier date, but it is nevertheless true that the vessels put in hand under the Naval Defence Act marked a real beginning. The preamble of the Act was as follows: "It is expedient that a sum not exceeding £21,000,000 be granted for the purpose of building, arming, equipping, and completing for sea vessels of Her Majesty's navy; and that it is expedient that a sum not exceeding £10,000,000 be issued out of the consolidated fund in seven years, ending the 31st of March 1896; and that a sum not exceeding £11,000,000 be issued out of the moneys to be provided by Parliament for the naval service during the financial years ending the 31st of March 1894." A subsequent measure supplemented the Act of 1889, and was described as the Naval Defence Act 1893, 56 & 57 Vict. cap. 45: "An Act to make further provision for the completion and equipment of ships under the Naval Defence Act 1889, and to amend that Act," and the new provision made was for a grant of moneys not exceeding £1,350,000. The programme of the Naval Defence Act was for the building of ten battleships, of which eight were of the first class, and displaced 14,150 tons, while two, which were then described as of the second class, but are now ranked of the first, were of 10,500 tons. The eight larger battleships built under the Act were the *Royal Sovereign*, *Empress of India*, *Hood*, *Ramillies*, *Repulse*, *Resolution*, *Revenge*, and *Royal Oak*, and the two smaller ships the *Centurion* and *Barfleur*. These are all ships of high freeboard, the larger ones with four 13·5-inch and the smaller with as many 10-inch guns in their barbettes, and in the matter of protection they marked a great advance upon their predecessors. The Naval Defence Act also provided for the building of nine first-class cruisers—the *Royal Arthur* and the *Crescent* (7700 tons), and the *Edgar*, *Endymion*, *Gibraltar*, *Grafton*, *Hawke*, *St. George*, and *Theseus*, as well as thirty-three second-class cruisers. The second-class cruisers were to be of 3400 tons, but before the programmes could be carried out the dimensions of several of them were increased to 4360 tons. The end of the financial year 1894-95 saw the completion of five second-class cruisers and four torpedo gunboats, which brought to an end the work provided for under the Naval Defence Act. The vessels were soon completed for sea, and most of them were commissioned for the manœuvres of 1895. The limit of five years, which had originally been fixed for the completion of these vessels, had been somewhat exceeded.

Naval programmes, 1892-1902.

Meanwhile provision had been made in the programme of 1892-93 for the laying down of the battleship *Renown*, displacing 12,350 tons and lying midway between the *Royal Sovereign* and *Centurion* classes, as well as for certain destroyers and other torpedo craft. It was on 23rd June 1893, off the coast of Tripoli, Syria, that the lamentable catastrophe occurred in which the *Victoria*, flagship of Sir George Tryon, commander-in-chief in the Mediterranean, was lost through collision with the *Camperdown*. This incident, combined with a strong feeling that after the close of the principal work of the Naval Defence Act no adequate provision had been made, caused Earl Spencer, then First Lord of the Admiralty, to introduce a new programme. In December 1893 Sir William Harcourt had told the House of Commons that the professional advisers of the Admiralty—meaning the Naval Lords—were of opinion that the navy was in a satisfactory state, and that its supremacy was for the moment absolute, and added that he would undertake to say that the "superiority of the British navy was never so great as it is now." It was commonly believed that the Naval Lords thereupon resolved to resign, but two days later Sir William Harcourt made a statement which modified the impression he had given. The agitation of that time materially strengthened the hands of Lord Spencer, and the programme of 1893-94 provided for the laying down of two new battleships—the *Majestic* and *Magnificent*—of 14,900 tons, afterwards first and second flagships of the Channel squadron, as well as three second-class cruisers—the *Talbot*, *Eclipse*, and *Minerva*—and two sloops. Two first-class cruisers—the *Powerful* and *Terrible*—belong to the same year, and after being deferred were given out to contract in December 1893. They were the first large vessels of the British fleet to be provided with water-tube boilers, these being of the Belleville type. The shipbuilding programme of 1894-95 included seven battleships, six cruisers of the second class, and two sloops. The battleships were of the *Majestic* class, and received the names of *Prince George*, *Victorious*, *Cæsar*, *Hannibal*, *Illustrious*, *Jupiter*, and *Mars* (14,900 tons). The second-class cruisers were the *Venus*, *Diana*, *Dido*, *Isis*, *Juno*, and *Doris*, displacing 5600 tons. All these were built by contract, as was the case with two of the battleships of that year. The shipbuilding work put in hand under this programme gave full occupation to the building yards, and the constructive scheme embodied in the estimates of 1895-96 did not include any battleships. There were four first-class protected cruisers of 11,000 tons, resembling in various ways the *Powerful* and *Royal Arthur* classes—the *Diadem*, *Andromeda*, *Europa*, and *Niobe*—all provided with Belleville boilers, and calculated for a speed of 20·5 knots; four second-class cruisers of 5750 tons—the *Arrogant*, *Furious*, *Gladiator*, and *Vindictive*; two third-class cruisers of 2135 tons—the *Pelorus* and *Proserpine*; and twenty torpedo-boat destroyers. The work conducted under the programme so far described was carried out with great rapidity. The *Majestic* and *Magnificent*, built respectively at Portsmouth and Chatham, were commissioned within twenty-two and twenty-four months from the laying of the keel, thus surpassing all previous records, and the *Prince George* at Portsmouth and the *Victorious* at Chatham maintained this rapidity of construction. Moreover the progress made with these vessels did not interfere with the maintenance of the progress intended either on new shipbuilding or in keeping up the sea-going and fighting efficiency of ships in reserve or commission. Good progress was also attained with the remaining five ships of the *Majestic* class, though in subsequent years, owing to strikes in the engineering trade and some other circumstances, the work was much impeded. The programme of 1896-97 included five battleships, of which three—the *Goliath*, *Canopus*, and *Ocean*—were built in the dockyards, and two—the *Albion* and *Glory*—by contract on the Thames and the Clyde. They are of a new class, displacing 12,950 tons, standing midway between the *Renown* and the *Majestic*. The programme also included four first-class protected cruisers of the *Diadem* class (11,000 tons)—the *Spartiate*, *Argonaut*, *Amphitrite*, and *Ariadne*; three second-class cruisers of 5600 tons—the *Hermes*, *Highflyer*, and *Hyacinth*; six third-class cruisers of 2135 tons—the *Pomone*, *Prometheus*, *Pegasus*, *Pyramus*, *Pactolus*, and *Perseus*; and twenty-eight torpedo-boat destroyers. Of the first-class cruisers, the *Spartiate* was laid down at Pembroke, and the others in private yards. The vessels under construction during this year comprised thirteen battleships, ten first-class cruisers, sixteen second-class cruisers, seven third-class cruisers, and a number of destroyers; and the expenditure involved considerably exceeded that incurred in any previous financial year, and the numbers and type of the new ships laid down were exceptional. The progress made was in many ways good, the *Mars* and *Jupiter*, for example, being delivered by the contractors five months within the contract date. Some of the ships were, however, greatly retarded by the dispute in the engineering trade. The *Cæsar*, *Illustrious*, and *Hannibal* were delayed, and some of the ships of the *Canopus* class, though rapidly pushed forward until the engineering dispute began, were, owing to the non-delivery of structural portions, much retarded. Progress with certain of the cruisers was also impeded. In the shipbuilding programme of 1897-98 four battleships were included—the *Vengeance*, of the *Canopus* class, built at Barrow, and the *Formidable*, *Implacable*, and *Irresistible* (*Majestics* with some improvements), constructed in the dockyards. The programme also included three third-class cruisers, two sloops, four gunboats, two torpedo-boat destroyers, and a new royal yacht, which was built at Pembroke. In addition, Mr Goschen, then First Lord, announced in July 1897 that in consequence of the proposed additions to the navies of foreign Powers, he had received an additional sum of £500,000 from the chancellor of the exchequer, wherewith it was proposed to begin the construction of four armoured cruisers of an entirely new design, which, it was said, would be capable both of commerce protection and of taking their place in the line of battle. These were the *Cressy* and *Aboukir*, built at Glasgow, the *Hogue* at Barrow, and the *Sutlej* at Clydebank—all displacing 12,000 tons. This extensive programme was very seriously affected by the prolonged labour disputes, which lasted from July 1897 until February 1898, and Mr Goschen confessed that the Board was unable to foresee the exact amount by which the anticipated expenditure on new constructions would fall short. The difficulties arising from the labour dispute affected the production of machinery, gun-mountings, armour, and almost every important class of material, and in the dockyards the work was delayed by the inability of the contractors to deliver the material they had undertaken to supply. The commencement of the armoured cruisers was also delayed by the introduction and trial of new types of 12-inch and 6-inch guns. Nevertheless the estimates of 1898-99 proposed to build three battleships of 15,000 tons and of the *Formidable* class—the *London*, *Venerable*, and *Bulwark*; and to put in hand also two armoured cruisers of the *Cressy* class—the *Euryalus* and *Bacchante*; and two others—the *Drake* and *King Alfred*—of a still larger type, displacing 14,100 tons, as well as four sloops. The year 1898-99 was also marked by the introduction of a supplementary shipbuilding programme. It was explained by the First Lord, in July 1898, that the programme at first presented was considered adequate at the time, and was based on the principle that the British navy must be equal in number, but superior in power, to the fleets of any two countries. Mr Goschen stated that it was impossible to conceal the fact that the action of Russia, and the programme on which she had entered, was the cause of this further strengthening the fleet. Mr Goschen's explanation was enforced in these words: "What, then, is our position? We know of six Russian battleships to be laid down this year, including one already begun. We have now verified where those six ships are to be built. Of those I took two into account in my original estimate, so that the balance against us was four. Accordingly, I must ask the House to sanction four battleships beyond my original estimate. The new Russian programme also provides for four cruisers from the commencement of this year, and we propose to commence an equal number—that is to say, four cruisers in addition to those provided for already." The supplementary programme, therefore, provided for the laying down of four battleships and four armoured cruisers, as well as twelve destroyers, and the total liability involved was about £8,000,000, to be spread over about three and a half years. The four new battleships were the *Duncan*, *Cornwallis*, *Exmouth*, and *Russell*, all built by contract, displacing 14,000 tons, and intermediate in size between the *Formidable* and *Canopus* classes with superior speed and thinner armour, the latter being due to improved processes of steel-production. The armoured cruisers were the *Leviathan* and *Good Hope*, both of the *Drake* class (14,100 tons), and the *Bedford* and *Monmouth* of a smaller type (9800 tons). Shipbuilding progress was still impeded, work being much disarranged owing to the unprecedented activity in mercantile shipbuilding which followed the labour dispute, and serious delay resulted from the inability of the shipbuilding contractors to procure the necessary materials. The ships could not thus be laid down nor carried forward so advantageously as had been hoped, and further delay occurred owing to the introduction of the Krupp process of armour, which made necessary the reconstruction of steel-producing plant. The programme of 1899-1900 included two other battleships—the *Montague* and *Albemarle* (14,000 tons)—of the *Duncan* class, and two armoured cruisers—the *Kent* and *Essex* (9800 tons)—of the *Bedford* class, all to be built in the dockyards, as well as three smaller cruisers, two sloops, and two first-class torpedo boats. Once more it proved that abnormal activity in shipbuilding and engineering seriously affected building progress, and checked expenditure on ships, machinery, and armour. Delay in the delivery of material, difficulties in securing adequate numbers of workmen, and other circumstances caused the aggregate earnings on contract work to fall short of the estimated amount by about £1,400,000, although the estimate had been calculated on the basis of actual earnings in past years of ships of similar character, and on close investigation of the possible output of armour. Progress in the dockyards was also impeded, and was further affected by the fact that a large number of the ships were designed for exceptionally high speed, and were therefore to be provided with propelling machinery of great power. The shipbuilding programme of 1900-1 included two battleships—the *Queen* and *Prince of Wales*; six first-class armoured

Delays in construction.

cruisers—the *Cornwall*, *Suffolk*, *Cumberland*, *Lancaster*, *Donegal*, and *Berwick*; one second-class cruiser (an improved *Hermes*), two sloops, two light-draught gunboats, and two torpedo boats. The programme of 1901-2 included three battleships, six armoured cruisers, two third-class cruisers, ten destroyers, five torpedo boats, two sloops, and five submarine boats. Shortly after the estimates were presented the Admiralty Boiler Committee made an interim report, in which the Belleville boiler was condemned, and a trial of other water-tube types recommended.

It may be useful to add a note concerning the spending of the money. Within the Controller's Department, as has been explained, are centred the more important spending branches of the Admiralty. While the work of designing ships and preparing plans is in progress, the director of stores, the director of dockyards, and other officials of that department concerned are making preparation for the work. The necessary stores, comprising almost every imaginable class of materials, are brought together, and the director of stores is specially charged to obtain accurate information in regard to requirements. He is not, however, a purchasing officer, that work being undertaken by the director of navy contracts, who is concerned with the whole business of supply, except in regard to hulls and machinery of ships built by contract, and the special requirements of the director of works. At the same time, the civil departments of the Admiralty being held responsible for the administration of the votes they compile, it is their duty to watch the outlay of money, and to see that it is well expended, the accountant-general being directed to assist them in this work. The system is closely jointed and well administered, but it possesses a very centralized character, which interferes to some extent with flexible working, and with the progress of necessary repairs, especially in foreign yards. In so far as ships given out to contract are concerned (and the same is the case in regard to propelling machinery built by contract), the director of navy contracts plays no part, the professional business being conducted through the Controller of the navy, who is advised thereon by the director of naval construction and the engineer-in-chief. The work conducted in private establishments is closely watched by the Admiralty officials, and is thoroughly tested, but, *mutatis mutandis*, the system in regard to contract-built ships is practically the same as that which prevails in the dockyards.

Expenditure.

V. *Personnel.*—No work of the Admiralty is more important than the supply of trained officers and men to the fleet. The provision of these in adequate number, the organization of the training service, the constitution of the reserve, and many other questions connected with the pay, promotion, and retirement of officers and men impose a great duty upon the Admiralty Board. The work mainly lies in the province of the second Naval Lord, who has charge of the work of manning the fleet, and educating and training the personnel, together with the affairs of the royal marine light infantry and the royal marine artillery. Within his purview are all training establishments, including those for engineer students, the naval colleges, and the royal marine schools. The First Lord of the Admiralty has special charge of promotions and removals of naval and marine officers to or from the service, and of the appointments of flag officers, captains, all officers to command ships, commanders to the coast-guard, superior officers to the medical service, staff appointments to the royal marines, and civil appointments and promotions, except where these fall under the Controller and the Civil Lord. The first Naval Lord appoints commanders (second in command), and the second Naval Lord navigating officers and lieutenants, sub-lieutenants, midshipmen, cadets, engineer officers, and others, while the appointment of chaplains, naval instructors, junior medical officers, paymasters, and other officers of the accountant branch falls to the junior Naval Lord. The increase of the matériel of the fleet has led to large additions being made to the numbers of officers and men, and the conditions of service have been in some ways modified. The general regulations are published in the *Quarterly Navy List*, so that it is unnecessary to refer to them here. The great scarcity of lieutenants caused the Admiralty, in the year 1895, to institute a supplementary list of naval lieutenants and sub-lieutenants, who were appointed under special conditions from the mercantile marine, and are not promoted beyond the rank of lieutenant unless for distinguished service, but are retired at forty-five years of age. Changes have also been introduced in the conditions and service of the royal naval reserve, and it may be said that the system of training is still under trial and that it is not yet definitely established. The number of officers, seamen, boys, coastguard, and royal marines borne on the books of His Majesty's ships and at the royal marine divisions are fixed yearly by vote A of the navy estimates. The following table shows the annual increase in the number in these ranks and ratings during the ten years 1890-1900:—

Year.	Total Number borne at end of Year.	Increase during Year.
1890-91 . .	67,748	1764
1891-92 . .	71,423	3675
1892-93 . .	74,420	2997
1893-94 . .	77,976	3556
1894-95 . .	63,117	5141
1895-96 . .	88,674	5557
1696-97 . .	94,376	5702
1897-98 . .	100,052	5676
1898-99 . .	106,002	5950
1899-1900 . .	111,019	5017

The total force voted for the year 1900-1 was 114,880, being an addition of 220 officers, 3050 petty officers and seamen, 150 engine-room staff, 200 miscellaneous ratings, 300 marines, and 320 apprentices (artisan ratings), making in all an addition of 4240. A further increase of 3745 was authorized in the next year. The number of officers is being increased under a scheme extended gradually over a certain number of years, and it was announced in 1899 that the flag officers would be increased from 68 to 80, the captains from 208 to 245, the commanders from 304 to 360, and the lieutenants from 1150 to 1550. Increases were also instructed to be made in the other branches of the service. The additions made to the matériel of the navy had outrun the provision made for the supply of officers, and the list of supplementary lieutenants was increased to tide over the interval which would elapse before a sufficient supply of executive officers trained up in the service could be produced in the ordinary course, it being easier to build ships than to train those required to man them.

Except for the list of supplementary lieutenants and sub-lieutenants which has been referred to, all executive officers of the navy enter as cadets upon the nomination of the First Lord of the Admiralty (who also nominates assistant clerks for the accountant branch) and are trained in the naval establishment now located in the *Britannia* at Dartmouth, which is about to be transferred to a building ashore. A few nominations are given to the sons of colonial gentlemen and of naval and military officers for special reasons of service, and in particular cases a few youths are entered from the *Worcester* and *Conway* training-ships of the mercantile marine. Latterly, a new arrangement as regards the entry and training of cadets has been instituted, and came into force in the year 1897-98. The result is gradually to raise the age for entering by one year, and to shorten the course of instruction in the *Britannia* to about sixteen months, and cadets are now entered three times a year instead of twice. The effect of this change is that about 190 cadets pass through the *Britannia* yearly instead of 125, as was the case formerly, and that 170 sub-lieutenants will be ultimately produced annually instead of 116. The question of a limited competition as compared with an open one has been much discussed. It has been argued that it is anomalous to have open competition for some branches and limited competition for others, and that the exercise of the right of nomination by the First Lord is liable to be influenced by political considerations.[1] After passing a certain time afloat, or in the case of the most successful boys at the date of their leaving the *Britannia*, the cadets are appointed midshipmen, and upon gaining the age of nineteen and completing three and a half years' service afloat as midshipmen, they may pass for sub-lieutenants, the examination being in seamanship, navigation, torpedo, gunnery, and pilotage. As an acting sub-lieutenant the young officer proceeds to the Royal Naval College, Greenwich, where his navigation and pilotage examination takes place, and he then passes to the gunnery and torpedo establishments at Portsmouth, where upon passing the examination he is confirmed in the rank of sub-lieutenant. Promotion to lieutenant depends upon the class of certificates obtained at these examinations. Thus, five first-class certificates and promotion-marks secure the promotion of the sub-lieutenant after six months from the date of seniority in that grade, five ordinary first-class certificates after twelve months, and so on down to twenty-seven months as sub-lieutenant, after which promotion is only by seniority. The duties of a lieutenant afloat are many and various, and include the charge of watches and of a division of men, with drill at the guns. A certain number of lieutenants specially qualify in gunnery, torpedo, and navigation, and are appointed to ships to act in the capacity of specialists in these matters. Above the rank of lieutenant promotion is by selection, twice a year, according to the needs of the service, a certain number of lieutenants being promoted to the rank of commander. Lieutenants are also promoted to commander from the royal yacht and for distinguished service. Before this time, however, a separation of duties may have occurred, for it is open to a certain number of lieutenants, under particular conditions, to be transferred to the coastguard, and to forego further chances of promotion. Captains are promoted by selection from the commanders' list, and captains, like officers of every other branch, are retired under the limit of age applicable to their rank. Their promotion to flag rank is by seniority, and depends upon the vacancies arising in the rear-admiral's list. In the same way rear-admirals rise to vice-admirals and admirals by seniority, but are promoted "admirals of the fleet" by selection.

Promotion of officers.

The position and pay of officers of the engineer branch has steadily improved during recent years. They enter between the ages of fourteen and seventeen, mostly by competitive examination, though a few nominations remain with the Admiralty. The course at the Royal Naval Engineers' College at Keyham is of four or five years. The most successful students at the final examinations go to the Royal Naval College, Greenwich, for a further course, and the most successful of these may be appointed to the royal corps of naval constructors. The less successful students are appointed probationary assistant engineers, and are confirmed in the rank after a period of service. Assistant engineers may pass for engineers after three years' service, and are eligible for promotion after five years' service. Promotion to chief engineer is by seniority as vacancies occur, and further promotion to inspector of machinery is by selection, and to chief inspector of machinery by seniority, these last two ranks being for officers appointed to various establishments at home and abroad.

The entry of accountant officers is like that of cadets, by nomination and limited competition, and under recent regulations the entry is made between the ages of seventeen and eighteen. The successful candidates are assistant clerks, passing after twelve months as clerks, and at the age of twenty-one, upon examination, become assistant paymasters. Promotion to paymaster is by seniority, and by qualifying time afloat there is promotion to staff-paymaster, and fleet-paymaster. Admirals' secretaries are selected from the ranks of assistant paymasters and paymasters.

Officers of the medical branch must be qualified under the Medical Act, and upon examination the candidates are appointed surgeons in the royal navy, and are specially trained at Haslar Hospital. After twelve years' full-pay service surgeons are advanced to the rank of staff-surgeons, and after a further period the rank of fleet-surgeon is gained. The deputy inspector-general is selected from the fleet-surgeons' list, and the inspector-general of hospitals and fleets from among the deputy-inspectors.

Chaplains are appointed to the fleet by the Admiralty after examination. They must have been ordained deacons or priests in the Church of England, or be of the same orders "by the lawful authority of one of the churches within the realm of Great Britain and Ireland which are in communion with the Church of England." In addition to his clerical duties the chaplain may act as naval instructor, but there is a special branch of naval instructors who are found qualified after attaining at least a "senior optime" at Cambridge, a second class in the final mathematical schools at Oxford, or junior moderator in pure or mixed mathematics at Dublin. These officers are further trained at Greenwich, and it is only after passing a qualifying examination that chaplains can also undertake the duties of naval instructors.

The royal naval reserve is an extremely popular force composed of officers (and others) of the mercantile marine —lieutenants, sub-lieutenants, senior engineers, and engineers, assistant engineers, and midshipmen. These officers are entered by the Admiralty upon certification by the Board of Trade, under regulations which are found in the *Quarterly Navy List*. Many of them undergo twelve months' training in ships of the fleet, and all those on the active list are required to drill on board one of the royal naval reserve drill-ships for a certain number of days yearly. The number of those on the list who had served or were serving was 267 in April 1900. Vacancies for executive officers of the reserve are filled as soon as they occur, and many qualified candidates present themselves for every vacancy. In 1898-99 provision was made for increasing the executive officers' list by 100, and the establishment of engineer officers of the royal naval reserve has been fixed at 400. The fleet reserve is a new organization devised to secure the retention of time-expired men on a system analogous to that of the army reserve.

The royal marines (*q.v.*), including the royal marine artillery and the royal marine light infantry, the former with their headquarters at Eastney, and the latter with their divisions at Chatham, Portsmouth, and Plymouth, are an extremely fine body of men, who serve alternately afloat and ashore. Candidates for commissions enter through the Civil Service Commissioners' examination at the Royal Military Academy at Woolwich, and upon passing out as second lieutenants the officers proceed to the Royal Naval College, Greenwich, after which there is training at the gunnery establishment at Portsmouth. In the case of the light infantry the training is similar, though there are some differences in procedure. A marine officer on board ship is in command of all marines in their distinct duty as such, but he cannot assume any naval command whatever, unless ordered to do so by the senior naval officer.

---

[1] See appendix to the *Life of Admiral Lord C. Paget*, who was for six years parliamentary secretary of the Admiralty.

Details in regard to qualifications, pay, emoluments, and duties, may be found in the *Admiralty Instructions* and the *Quarterly Navy List*.

Men.

We may now turn from the officers to the men. Boys are entered in the training-ships between 14½ and 16¾ years of age, and they undergo a course of instruction to qualify them for seamen, having on entry signed an agreement to serve for twelve years from the age of 18, after which they can claim their discharge. When the course of training in the training-ships and brigs is sufficiently advanced the boys proceed on active service. Many boys are periodically drafted to the ships of the Channel squadron, and there become ordinary seamen. The next rating to which men rise by service and good conduct is that of able seamen, and the various ratings of petty officers to that of chief petty officer follow. A certain proportion of men may become warrant officers (gunners, boatswains, &c.), a most valuable class of men, and these may rise to commissioned rank in the case of special gallantry against the enemy. Pensions are granted at the age of forty to seamen who have served for twenty-two years from the age of eighteen, according to conduct, ability, and advantage. Stokers are entered direct from the shore, serve some time in the steam reserve to be taught their drill and learn the discipline of the service, and go out on steam trials before being sent to a sea-going ship. Like the seamen they can rise from petty officer to warrant officer, a rank which gives a pension to the widow. The artificer class, which comprises blacksmiths, armourers, plumbers, carpenters, &c., have to pass an examination in their trade before being sent to sea-going ships. As is the case with officers, there may come a time when the petty officer may think it desirable to join the coastguard, which gives him duties on shore, but places him only in the rank of able seaman, while his gunnery and torpedo pay are stopped.

Allusion has been made to the officers of the royal marine forces. The men are enlisted for twelve years, and the service may be extended to twenty-one years. The recruit receives his first training at the depôt at Walmer and may volunteer for the artillery branch in which the pay is better, and be transferred to it upon fulfilling the conditions. His duties ashore are those of a soldier, but when the time comes he is drafted for service afloat, and his duties then are in many respects analogous to those of the seamen. The royal marines, both of the artillery and light infantry branches, are an extremely fine body of men who have never failed to do good service when called upon, and the force has been largely increased within recent years. The average height of the men on entry has lately ranged from 5 feet 7½ inches to 5 feet 8 inches for the royal marine artillery, and from 5 feet 5¼ inches to 5 feet 6 inches for the royal marine light infantry. The numbers of the corps are being steadily increased, and in the year 1901-2 there was a further addition to the force of 1000 men. The marines—their barracks, drill, and books—are inspected by the deputy adjutant-general of royal marines, and their discipline is entirely under him, nor can they be sent away from their headquarters except by orders from the Admiralty. For garrison and field duties they are, when their naval duties so permit, under the general commanding the forces at their headquarters.

Training.

In the year 1899, at the commencement of the South African war, the masted training squadron which had been employed for the training of the boys of the seamen class, as well as of young officers, was replaced by a squadron composed of modern cruisers. This circumstance led to a discussion concerning the right system of training boys for service afloat. The question had been debated before, but in June 1900 Mr J. R. Thursfield read a paper upon the subject before the Royal United Service Institution, which was followed by an important discussion. The argument of the lecturer was that, though masted ships are no longer used in the navy, the training or discipline of masts and sails was well adapted to educe those qualities of alertness, readiness, quickness of eye, and rapidity of decision which are universally thought essential in seamen. On the other hand, a large number of naval officers were of opinion that the system implied by the existence of the small training squadron of masted vessels had given anything but satisfactory results. One after another various admirals who had lately commanded fleets, or who were then in command, testified to the need of some system of training which would restore the type of officer and seaman which they affirmed to be disappearing. The majority of these were of the opinion that no mere resuscitation of a training ship squadron of four-masted vessels would remedy the evil, while some ridiculed the idea of attempting to revive what they looked upon as dead and buried. It was very noteworthy, on the other hand, that some young officers appeared as stout advocates of the old system of training. In short, the discussion revealed the existence of two schools of thought on this important matter, and on either side were ranged officers of equal rank and experience. There was a consensus of opinion that something was needed for the training of the fleet, but a wide divergence of view was revealed as to what that something should be. It may be worth while to remark that the men of the naval brigade on the Benin expedition under Sir Harry Rawson, and those lately employed in South Africa and China, showed no deterioration in the characteristic handiness of the seaman.

VI. *Mobilization of the Fleet.*—By the mobilization of the fleet is meant the placing of naval resources upon a war footing, in readiness in all material and personal respects for hostile operations. It is obvious that this is the real crown and completion of the work of the Admiralty Board, and that there can be no department or branch which is not in some way concerned in it. The work of mobilization falls chiefly within the province of the first Naval Lord, and the mobilization branch of the Naval Intelligence Department is his agency. The essence of the work of that branch is described as "preparation for war," and it is concerned with the preparation of plans for organization, basing much of its work upon the information gained by the Foreign Intelligence Branch. The Naval Intelligence Department is a consultative office in the department of the first Naval Lord. But of course the second Naval Lord, who is chiefly concerned with the manning of the fleet, including the coastguard and the royal naval reserve, has a very large share in the duties of mobilization. The same may be said of the Additional Naval Lord and Controller, who is charged with all that concerns the matériel of the fleet, and again of the junior Naval Lord, whose duties are largely in the matters of transport and auxiliary services. A large amount of information concerning mobilization—as indeed concerning all other naval subjects—will be found in *The British Fleet*, by Commander Charles N. Robinson, R.N., from which some of the following notes are taken. He remarks that mobilization is the point to which everything naval tends. It is the duty of the Admiralty to provide ships in efficient condition, with ammunition, coal, stores, and supplies, complete in every material respect—this implying of course adequate naval bases and coaling stations—and the mobilization of the personnel is the bringing of every man in due time to the ship and the duties for which he is appointed. The mobilization for the naval manœuvres is only a partial operation, for a complete mobilization would dislocate our sea-faring life in a manner that would be justifiable only by actual war. Thus, the auxiliary cruisers of the mercantile marine are not mobilized, nor the pensioners, nor the men of the royal naval reserve, though large numbers of the latter are, of course, afloat during the manœuvres.

The Admiralty is the central authority which sets the operation of mobilization in motion, but the duties involved fall to the naval commanders-in-chief at the ports and to the admiral superintendent of naval reserves. "These high and important functionaries are collectively as the brain of the maritime body in direct communication, through various active sub-centres, with its outermost limits. From them emanate the instructions which give effect to the order to mobilize." The first step is to complete in any details the complements of the ships actually in commission, and in practice young officers from Greenwich and other training establishments are attached to them. By a recent arrangement, however, the reserve squadron, consisting of the coastguard and the portguard ships at the various ports, is maintained with complete complements, and assembles periodically for training. The order to mobilize sets in motion many officers and men of the coastguard, and opens the gangways and doors of the training establishments, depôts, barrack, and harbour ships. From these come the seamen, gunners, torpedo men, signalmen, and stokers, who have been undergoing special courses, as well as the boys from the training ships, the men who have had charge of machinery of ships in reserve, and, indeed, all classes of men required for ships commissioned, who are effective at the various quarters.

The arrangements made are admirably complete, and every man as he leaves his ship or depôt is provided with a card indicating his ship, station, and duties, so that he knows exactly where he is to go and what to do, and he falls into the plan precisely in the place which the careful paper scheme has provided for him. In this way the ships in the first division of the fleet reserve are provided with complements. These are the ships lying at the dockyards in every respect complete except for their crews, officers, stores, and ammunition. Meanwhile, the various victualling and store departments have been actively engaged in supplying every detail necessary for the ships, whose complements are completed by the embarkation of non-continuous service men, such as stewards and cooks. This is the point at which the annual mobilization generally stops short. But in case of hostilities it would, of course, go much further. Then the superintendent of naval reserves would be charged with the duty of supplying successive contingents of men to the naval ports to take the place of those sent afloat, these contingents to embark in their turn in the ships brought forward for commission, and to be succeeded again by others, according as the need arose. This work would begin from the headquarters of the coastguard divisions at Harwich, Hull, Queensferry, Greenock, Kingstown, Limerick, Holyhead, Portland, and Southampton. The officers and men of the coastguard would go afloat comparatively early in the operations, and, in fact, a number of them go to sea annually during the manœuvres. Meanwhile, the officers and men of the royal naval reserve and the pensioners would have been set in motion to their respective drill-ships and barracks, and having been embodied would be converged upon the special naval ports where their services were required. In this way the ships in other classes of the reserve would receive their complements, as well as the auxiliary cruisers taken up from the merchant marine. As Commander Robinson remarks: "It is impossible to say where, in a great national crisis, the mobilization of men would end; for all the sea-faring manhood of our islands, all our artisan population—boilermakers, engine-fitters, electricians, engineers, carpenters, and a host of others, would render their best in the empire's need." The work would not end with the provision of complements for the ships, and a hundred other considerations would occupy the mobilizing authorities. They would be engaged in passing men through the special training ships to form the eventual complements of ships, or to replace those killed in action, and they would also have to supply efficient men for the signalling stations and for other duties.

A word has been said about the material requirements of the fleet upon mobilization. These are largely centred in the branches of the director of stores and the director of victualling. The former is concerned with the supply of a vast array of objects and necessaries, including coal, boats, oil, rope, candles, paint, varnish, and a host of other things. Adequate supplies are kept at the depôts, and the work of replenishment in case of mobilization would go forward steadily. The director of victualling being responsible under the junior Naval Lord for regulating the proper supply, care, and preservation of all victualling and clothing stores for the fleet, including mess-traps and seamen's utensils, and having charge of the victualling yards and depôts, maintains constantly adequate quantities at the various stations; and it may be useful to say that the chief victualling yard at home is that at Deptford, the others being at Portsmouth and Devonport, with a smaller establishment at Haulbowline (Queenstown), while there are depôts abroad at Gibraltar, Malta, Halifax, Bermuda, Jamaica, the Cape of Good Hope, Trincomalee, Hong-Kong, Esquimalt, Bombay, Ascension, Coquimbo, and Sydney. All these, of course, are supplied with a great quantity of stores that would play a most important part during a complete mobilization of the fleet.

VII. *Naval Finance: The Accountant-General's Department.*—The subject of naval finance is one of great complexity and of vast importance. The large sums of money with which the Admiralty deals both in the way of estimates and expenditure, amounting recently to about £30,000,000 annually, implies the existence of the great organization which is found in the department of the accountant-general of the navy. Under the authority of the First Lord, the parliamentary and financial secretary is responsible for the finance of the Admiralty in general, and for the estimates and the expenditure, the accounts and the purchases, and for all matters which concern the relations of the Admiralty to the Treasury and to other departments of the Government; and in all the practical and advisory work the accountant-general is his officer, acting as his assistant, with the director of naval contracts who, under the several Lords, is concerned with the business of purchase.

The organization of the accountant-general's department has undergone many changes, and the resulting condition is the outcome of various modifications which have had for their purpose to give to this officer a measure of financial control. There have been various views as to what the duties of the accountant-general should be. After the reorganization of the Admiralty by Sir James Graham in 1832, the accountant-general was regarded as a recording and accounting officer, wholly concerned with receipt and expenditure. His duties were limited to the auditing of accounts, payments, and expenditure generally. Owing to changes effected in 1869, which made the parliamentary secretary, assisted by the Civil Lord, responsible for finance at the Admiralty, bringing the naval and victualling store departments into his charge, the accountant-general was invested with the power of criticizing these accounts financially, though he did not as yet possess any financial control, and the position was little changed by fresh rules made in 1876. It was not until 1880 that the powers of the accountant-general were enlarged in this direction. It was then ordered that he should be consulted before any expenditure which the estimates had not provided for was incurred, and before any money voted was applied to other purposes than those for which it was provided. The effect of this order was not happy, for the accountant-general could not undertake these duties without setting up friction with the departments whose accounts he criticized. It was contemplated by the Admiralty in 1885 to make the accountant-general the assistant of the financial secretary, and to raise him to the position of a permanent officer of finance instead of being an officer of account invested with imperfect authority in the direction of control. A select committee of the House of Commons reported that the accountant-general possessed no financial control over the departments, and that there was an urgent need for establishing such a control. At the time the position of that officer did not enable him to exercise any sufficient general supervision over expenditure, and there was no permanent high official expressly charged with finance. Accordingly, after being submitted to a departmental committee, a fresh arrangement was made in November 1885, whereby the accountant-general, under the authority of the financial secretary, was given a direct share in the preparation of the estimates. His written concurrence was required before the final approval of the votes, and each vote was referred to him for his approval or observations, and he was to exercise a financial review of expenditure and to see that it was properly accounted for. He became, in fact, "the officer to be consulted on all matters involving an expenditure of naval funds." It was believed that economical administration would result; but much opposition was raised to the principle that was involved of submitting the proposals of responsible departments to the inexpert criticism of a financial authority. Mr Main, assistant accountant-general, stated before the Royal Commission on Civil Establishments, 1887, that the effect had been to develop a tendency to withhold information or to afford only partial information, as well as to cause friction when questions were raised affecting expenditure, accompanied by protests, even in those cases in which these questions were manifestly of a legitimate character. The result was discouraging, and in the opinion of Mr Main had done much to weaken financial control and to defeat the purpose of the order. It is unnecessary to detail the various changes that have been made by the institution of dockyard expense accounts in the department of the Controller, and by various other alterations introduced. The Treasury instituted an independent audit of store accounts which greatly affected the position of the accountant-general, and the Royal Commission on Civil Establishments reported that the Board of Admiralty were of opinion that they could dispense with the accountant-general's review altogether. The commission was, however, of opinion that the accountant-general should be the permanent assistant and adviser, on all matters involving the outlay of public money, of the financial secretary.

The operations of the accountant-general are now conducted in accordance with the Order-in-Council of 18th November 1885, and of an office memorandum issued shortly afterwards. He thus acts as deputy and assistant of the parliamentary and financial secretary, and works with a finance committee within the Admiralty, of which the financial secretary is president and the accountant-general himself vice-president. The duties of the department are precisely defined as consisting in the criticism of the annual estimates as to their sufficiency before they are passed, and in advising the financial and parliamentary secretary as to their satisfying the ordinary conditions of economy. The accountant-general also reviews the progress of liabilities and expenditure, and in relation to dockyard expenditure he considers the proposed programme of construction as it affects labour, material, and machinery. He further reviews current expenditure, or the employment of labour and material, as distinguished from cash payments of the yard, as well as proposals for the spending of money on new work or repairs of any kind for which estimates are currently proposed. The accountant-general's department has three principal divisions: the estimates division, the navy pay division, and the invoices and claims division. In the first of these is the ledger branch, occupied with the work of accounts under the several votes and sub-heads of votes, and with preparing the navy appropriation account, as well as the estimates and liabilities branch, in which the navy estimates are largely prepared after having been proposed and worked out in the executive departments of the Admiralty. There are also ships' establishments and salaries branches. The navy pay division includes the full and half-pay branch and a registry section. There is also the seamen's pay branch, which audits ships' ledgers and wages, and has charge of all matters concerning the wages of seamen. The victualling audit is also in this branch, and is concerned with payments for savings in lieu of victualling and some other matters. Further, the navy pay division examines ships' ledgers, and is concerned with the service, characters, ages, &c., of men as well as with allotments and pensions. The third division of the accountant-general's department, known as that of invoices and claims, conducts a vast amount of clerical work through many branches, and is concerned with the management of Naval Savings Banks and matters touching prize-money and bounties.

The importance of this great department of the Admiralty cannot be overrated. It is, in the first place, of supreme importance that the navy estimates should be placed upon a sound financial basis; and in practice the board requires the concurrence of the accountant-general to the votes before they are approved, and thus in greater or less degree this officer is concerned in the preparation of every one of the votes. He does not concern himself with matters of larger policy outside the domain of finance, and it must be confessed that there appears to be something anomalous in his "review" of naval expenditure. It is, however, a mark of the flexibility or elasticity of the Admiralty system that in practice the operations of the accountant-general's department work easily, and that Admiralty finance is recognized as having been placed upon a sound and efficient basis. There are important financial officers outside the accountant-general's department concerned with assisting the Controller. The inspector of dockyard expense accounts, who is entirely in the Controller's department, enables him to exercise careful supervision over expenditure and the distribution of funds to special purposes. This work, however, though highly important, is merely one part of the system of financial control. Within recent years the bonds have been considerably tightened, and the work is untainted by corruption. It is true that in exercising rigid supervision over expenditure the work has become more centralized than is desirable, and it is a mark of change within recent years that local officers have been in larger measure deprived of independent powers. This, indeed, is a necessary condition of financial control, or at least a condition which it is not easy to change where rigid control is necessary. (R. V. H.; J. LD.)

UNITED STATES.

Navy Department.

The President of the United States is commander-in-chief of the navy—a constitutional prerogative which he seldom asserts. The Navy Department is administered by a civilian Secretary of the Navy—a cabinet officer appointed by the President—who exercises general supervision. Next in authority is the Assistant-Secretary, also a civilian nominee, who acts as an assistant, and has, besides, certain specific duties, including general supervision of the marine corps, naval militia, and naval stations beyond the continental limits of the United States. The details of administration are supervised by the chiefs of bureaus, of which there are eight. They are appointed by the President from the navy list for a period of four years, and have the rank of rear-admiral while serving in this capacity. They have direct control of the business and correspondence pertaining to their respective bureaus; and orders emanating from them have the same force as though issued by the Secretary.

The bureau of *Navigation* is the executive, or military, bureau, and as such promulgates and enforces the orders and regulations prescribed by the Secretary; it has general direction of the procurement, education, assignment, and discipline of the *personnel*. It also controls the movements of ships, including the authorization of manœuvres and drills, such as target practice. The bureau of *Equipment* has charge of all electrical appliances, compasses, charts, and fuel, and generally all that relates to the equipment of vessels, exclusive of those articles that come naturally under the cognizance of other bureaus. It has charge of the naval observatory, where the ephemeris is prepared annually, and of the hydrographic office, where charts, sailing directions, notices to mariners, &c., are issued. The bureau of *Ordnance* has charge of the gun factory, proving ground, and torpedo station, and all naval magazines; all the details that pertain to the manufacture, tests, installation, or storage of all offensive and defensive apparatus, including armour, ammunition hoists, ammunition rooms, &c., though much of the actual installation is performed by the bureau of construction after consultation with the bureau of ordnance. The bureau of *Construction and repair* has charge of the designing, building and repairing of hulls of ships, including turrets, spars, and many other accessories. It builds all boats, has charge of the docking of vessels and the care of ships in reserve. The chief of this bureau is usually a naval constructor. The bureau of *Steam engineering* has charge of all that relates to the designing, building, and repairing of steam machinery, and with all the steam connexions on board ship. The bureau of *Supplies and accounts* procures and distributes provisions, clothing, and supplies of the pay department afloat, and acts as the purchasing agent for all materials used at naval stations, except for the medical department and marine corps. It also has charge of the disbursement of money and keeping of accounts. The chief of this bureau is a pay officer. The bureau of *Medicine and Surgery* has charge of all naval hospitals, dispensaries, and laboratories, and of all that pertains to the care of sick afloat and ashore. The chief of this bureau is a medical officer. The bureau of *Yards and docks* has charge of construction and maintenance of wet and dry docks, buildings, railways, cranes, and generally all permanent constructions at naval stations. The chief of this bureau is often a civil engineer.

Under the cognizance of the Secretary's office is the office of the judge-advocate-general, an officer selected by the President from the navy list for a term of four years, with the rank of captain while so serving. He is legal adviser to the Department, and reviews the records of all courts and statutory boards. Under the cognizance of the Assistant-Secretary's office is the office of naval intelligence, which collates information on naval matters obtainable at home and abroad. The staff is composed of naval officers on shore duty, the senior in charge being usually a captain, and known as chief intelligence officer. Several boards are employed under the various bureaus, or directly as advisers to the Secretary. Some are permanent in character, while others are composed of officers employed on other duty, and are convoked periodically or when required. The naval policy board is composed of officers of high rank, and meets once a month; its duties conform to those of the general staff in armies. The board on construction consists of the chiefs of bureaus of Ordnance, Equipment, Construction and repair, Steam engineering, and the chief intelligence officer. Its duty is to advise the Secretary in all matters relating to the construction policy in detail. The general construction policy is suggested by the naval policy board. The board of inspection and survey is composed of representatives of all bureaus, who inspect vessels soon after commission and on return from a cruise, and report on the condition of the ship and efficiency of its *personnel;* it also conducts the official trials of new vessels. The boards for the examination of officers for promotion are composed of officers of the corps to which the candidate belongs and of medical officers. Every officer is examined professionally, morally, and physically at each promotion. The Navy Department is located at Washington, D.C., and occupies a building together with the State and War Departments (the latter being charged solely with army affairs).

Personnel.

The *personnel* is limited in number by law. The allowance of commissioned officers in July 1900 was 1449, distributed as shown in the table. All others than line officers are termed, in contradistinction from them, staff officers. The relative navy or army rank of any staff grade may be ascertained from the table on p. 79.

The engineer corps was abolished in 1899, the then engineer-officers becoming line officers in their respective relative grades. Line officers are the military and executive branch, and are required besides to perform engineer duties. They are graduates of the Naval Academy. Vacancies occurring in the construction corps are filled from the graduates of the Naval Academy having the highest standing in scholarship, who are given a two years' graduate course, generally abroad, on being graduated from the Academy, and are then appointed assistant naval constructors. All other staff officers are appointed directly from civil life by the President, from candidates passing prescribed examinations. Each representative and delegate in Congress has authority to nominate a candidate for naval cadet whenever his congressional district has no representative in the Naval Academy. The candidate must be a resident of the district which the Congressman represents, between fifteen and twenty years old, and must pass prescribed mental and physical examinations. The President is allowed ten representatives at the Academy at all times, appointed "at large," and one appointed from the district of Columbia.

Line Officers (Executive Branch).	Medical Corps.	Pay Corps.	Naval Constructors.	Civil Engineers.	Chaplains.	Professors of Mathematics.	Relative Army Rank.
1 admiral	..	..	..	..	..	..	General
9 rear admirals	..	..	..	..	..	..	Major-gen.
9 ,, ,,	..	..	..	..	..	..	Brig.-gen.
70 captains	15 medical directors	13 pay directors	5 naval constructors	2 civil engineers	4 chaplains	3 prof. of math.	Colonel
112 commanders	15 medical inspectors	13 pay inspectors	5 ,, ,,	2 ,, ,,	7 ,,	4 ,, ,,	Lieut.-col.
170 lieut.-coms.	55 surgeons[1]	40 paymasters[1]	30 naval constructors and assist. naval constructors[4]	2 ,, ,,	13 ,,[1]	5 ,, ,,[1]	Major
300 lieutenants	110 passed assistant-surgeons and assist.-surgeons.[2]	30 passed assist.-paymasters[2]	..	4 ,, ,,	..	..	Captain
350 { lieutenants (junior grade)	..	40 assistant paymasters[3]	..	11 ,, ,,	..	..	1st lieut.
ensigns	..	..	..	..	..	..	2nd lieut.
1021 total.	195 total	136 total	40 total	21 total	24 total	12 total	

[1] With rank of lieut.-commander or lieutenant. [2] With rank of lieutenant, or lieutenant (junior grade). [3] With rank of lieutenant (junior grade) or ensign.
[4] Naval constructors with rank of lieut.-commander or lieutenant. Assistant naval constructors have rank of lieutenant, or lieutenant (junior grade).

The course of instruction at the Academy is four years, each comprising eight months' study, three months' practice cruise, and one month's furlough. At the expiration of four years, cadets are sent to cruising ships for two years' further instruction, and are then commissioned ensigns. After three years' further sea service, ensigns are promoted to lieutenants (junior grade). After this, promotion is dependent upon seniority alone, the senior officer in any grade being promoted to the lowest number in the next higher grade when a vacancy occurs in the higher grade, and not before. All officers are retired on three-fourths sea pay at the age of sixty-two, or whenever a board of medical officers certifies that an officer is not physically qualified to perform all duties of his grade. A few officers are allowed to retire voluntarily in certain circumstances, to stimulate promotion. Any officer on the retired list may be ordered by the Secretary to such duty as he may be able to perform: this is a legal provision to provide for emergencies. Promotion in the staff corps is dependent upon seniority, though relative rank in the lower grades in some corps somewhat depends upon promotion of line officers of the same length of service, and accounts for the existence of staff officers in the same grade having different ranks. All sea-going officers, after commission, are required to spend three years at sea, and are then usually employed on shore-duty for a time, according to the needs of the service — short terms of shore-duty thereafter alternating with three-year cruises. This rule is adhered to as strictly as circumstances will permit. Shore duty includes executive or distinctly professional duties in the Navy Department, under its bureaus, and at navy yards and stations; inspection of ordnance, machinery, dynamos, &c., under construction by private firms; duty on numerous temporary or permanent boards; instructors at the Naval Academy; recruiting duty; charge of branch hydrographic offices; inspection duty in the lighthouse establishment; at state nautical schools; as attachés with United States legations; and many others. Naval constructors (usually), civil engineers, and professors of mathematics are continuously employed on shore-duty connected with their professions, the Naval Observatory, Nautical Almanac, and the Naval Academy employing most of the last.

Warrant officers include boatswains, gunners, carpenters, sailmakers, warrant machinists, and pharmacists. The last are limited in number to twenty-five, and are stationed at hospitals, &c., ashore. Warrant machinists are at present limited by law to 150. The number of the others is at the discretion of the Secretary. The number in January 1901 was as follows: boatswains, 91; gunners, 95; carpenters, 62; sailmakers, 10. They are appointed by the Secretary, preference being given to enlisted men in the navy who have shown marked ability for the positions. They must be between twenty-one and thirty-five years of age, and pass an examination. After serving satisfactorily for one year under an acting appointment, they receive warrants that secure the permanency of their office. Ten years after appointment, boatswains, gunners, carpenters, and sailmakers, are eligible for examination for a commission as chief-boatswain, &c., and as such they rank with, but next after, ensigns. Mates are rated by the Secretary from seamen or ordinary seamen. They have no relative rank, but take precedence of all petty officers. Their duties approximate to those of boatswains, though they seldom serve on large cruising vessels. There were but eight on the active list in January 1901. Clerks to pay officers are appointed by the Secretary on the nominations of the pay officers. They have no rank and are not promoted or retired. Their appointments are revoked when their services are no longer needed.

The enlisted force numbers 20,000, including 2500 apprentices. Boys between fifteen and seventeen years old of good character, who can read and write and pass the physical examination, may enlist for the term of their minority. They enlist as third class apprentices, and are given six months' instruction at a training station, and thence go to sea in apprentice training vessels. When proficient they are transferred to regular cruising vessels as second class, and when further qualified are rated first class. All other enlistments are for four years. First enlistments are made only in the following ratings and between the ages specified:—

Rating.	Years of Age.
Seamen	21 to 35
Ordinary seamen	18 ,, 30
Landsmen	18 ,, 25
Shipwrights	21 ,, 35
Blacksmiths	21 ,, 35
Plumbers and fitters	21 ,, 35
Sailmakers' mates	21 ,, 35
Machinists, first class	21 ,, 35
Machinists, second class . . .	21 ,, 35
Electricians, third class . . .	21 ,, 35
Boilermakers	21 ,, 35

Rating.	Years of Age.
Coppersmiths	21 to 35
Firemen, first class	21 ,, 35
Firemen, second class	21 ,, 35
Coal-passers	21 ,, 35
Hospital stewards	21 ,, 30
Hospital apprentices, first class	21 ,, 28
,, apprentices	18 ,, 25
Officers' stewards	21 ,, 35
Officers' cooks	21 ,, 35
Mess attendants	18 ,, 30
Ship's cooks, fourth class	18 ,, 30
Musicians, first class	21 ,, 35
Musicians, second class	21 ,, 35
Buglers	21 ,, 35
Painters	21 ,, 35

Recruits must speak English. Landsmen are usually sent to sea on special training-ships until proficient, and are then sent into general service. Raw recruits may enlist as landsmen, or coal-passers, or mess attendants. Ordinary seamen must have served two years, and seamen four years before the mast, prior to first enlistment as such; and before enlistment in any other rating allowed on first enlistment, applicants must prove their ability to hold such rating. Landsmen, coal-passers, &c., as soon as they become proficient, are advanced to higher grades and, if American citizens, may eventually become petty officers (ranking with army non-commissioned officers), with acting appointments. In twelve months, or as soon thereafter as proficiency is established, the acting appointment is made permanent, and an acting appointment for the next higher grade is issued, &c. Permanent appointments are not revokable except by sentence of court-martial, and a man re-enlists in that rating for which he held a permanent appointment in his previous enlistment. All persons re-enlisting within four months after expiration of previous enlistment are entitled to a bounty equal to four months' pay, and in addition receive a "continuous service certificate," which entitles them to higher pay and to other special considerations. The same is true for each re-enlistment. When an enlisted man completes thirty years' service and is over fifty years of age he may retire on three-fourths pay.

Marine corps.

The marine corps constitutes a wholly separate military body, though under the control of the Navy Department. It is organized, equipped, uniformed, instructed, and drilled similarly to the army, both as infantrymen and artillerymen, and hence may be employed as soldiers either afloat or ashore. The corps is commanded by a brigadier-general, with headquarters in Washington, who bears to the Secretary a relation similar to that of a chief of bureau. The general has a general staff of ten members, and the remaining officers allowed by law are as follows: 5 colonels, 5 lieutenant-colonels, 10 majors, 60 captains, 60 first lieutenants, and 60 second lieutenants. Although the organization closely follows the army system, regimental or even permanent battalion organizations are impracticable, owing to their numerous and widely-separated stations. Practically all shore stations have barracks where marines are enlisted and drilled. At these places they also do sentry, police, and orderly duties. From such stations they are sent to ships for sea duty. Nearly all ships carry a body of marines known as the guard, varying in size from a few men commanded by a sergeant, on small ships, to eighty or more, with one or more commissioned officers, on large vessels. It is customary to cause all marines to serve at sea three of the four years of each enlistment. On board ship they perform sentry and orderly duty, and assist in police duties. They are also instructed in many exercises pertaining to the navy, as rowing, naval signalling, gun drill, &c. In action they act as riflemen, and on many ships serve a portion of the guns. When circumstances require a force to be landed from ships present to guard American interests in foreign countries, legations, &c., the marine guard is usually sent, though, if numerically insufficient, sailors are landed also. Large bodies of marines are sometimes sent in transports for this purpose from other stations. Marines also garrison places beyond the territorial limits of the United States which are under navy control. The enlisted force numbers 6000. Candidates for first enlistment must be between the ages of 21 and 35 and unmarried, must be citizens of the United States, be able to read, write, and speak English, and pass a physical examination. Second lieutenants are appointed from civil life after examination or from the graduates of the Naval Academy. Promotion is by seniority as in the navy. Occasional opportunities are also given meritorious enlisted men to secure commissions.

NAVY AND MARINE CORPS PAY TABLES.

TABLE I.—*Active List: Officers of the Line, Medical and Pay Corps of the Navy, and Officers of the Marine Corps.*

Rank.	On Sea Duty or Shore Duty beyond Sea.	On Shore.
	$	$
Admiral	13,500	13,500
Rear-admirals—		
First nine	7,500	6,375
Second nine	5,500	4,675
Chiefs of bureaus and brigadier-general commandant of marine corps	...	5,500
Captains, navy	3,500	2,975
Judge-advocate-general and colonels, marine corps, line and staff	3,500	3,500
Commanders, navy	3,000	2,550
Lieutenant-colonels, marine corps, line and staff	3,000	3,000
Lieutenant-commanders, navy	2,500	2,125
Majors, marine corps, line and staff	2,500	2,500
Lieutenants, navy	1,800	1,530
Captains, marine corps—		
Line	1,800	1,800
Staff	2,000	2,000
Lieutenants (junior grade), navy	1,500	1,275
First lieutenants and leader of band, marine corps	1,500	1,500
Ensigns, navy	1,400	1,190
Second lieutenants, marine corps, chief boatswains, chief gunners, chief carpenters, and chief sailmakers	1,400	1,400

Remarks.

All officers paid under this table below the rank of rear-admiral or brigadier-general are entitled by law to 10 per cent. upon the full yearly pay of their grades for each and every period of five years' service, as increase for length of service, or "longevity pay," computed upon their total actual service in army, navy, and marine corps; provided that the total amount of such increase shall not exceed 40 per cent. upon the full yearly pay of the grade; and provided further that the pay of a captain in the navy or colonel of marines shall not exceed $4500 per annum, and that of a commander in the navy or lieutenant-colonel of marines $4000 per annum.

ALLOWANCES.—The monthly commutation for quarters of the admiral is $125. All other commissioned officers of the line and of the medical and pay corps of the navy, and all officers of the marine corps, are entitled to public quarters while on shore-duty or commutation therefor, the amount varying between $24 per month for an ensign and $72 for a rear-admiral. Officers serving ashore in Cuba, Porto Rico, the Philippine Islands, Hawaii, or Alaska are allowed 10 per cent. increase of the pay proper.

TABLE II.—*Active List: Other Officers of the Navy and others who are paid as Officers.*

Rank.	First 5 Years after Date of Commission.			Second 5 Years after Date of Commission.			Third 5 Years after Date of Commission.			Fourth 5 Years after Date of Commission.			After 20 Years from Date of Commission.		
	At Sea.	On Shore or other Duty.	On Leave or waiting Orders.	At Sea.	On Shore or other Duty.	On Leave or waiting Orders.	At Sea.	On Shore or other Duty.	On Leave or waiting Orders.	At Sea.	On Shore or other Duty.	On Leave or waiting Orders.	At Sea.	On Shore or other Duty.	On Leave or waiting Orders.
Naval cadets—	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$
In other than practice ships	950														
At Naval Academy and elsewhere	500	500	500												
Chaplains	2500	2000	1600	2800	2300	1900									
Professors of mathematics and civil engineers	2400	2400	1500	2700	2700	1800	3000	3000	2100	3500	3500	2600			
Naval constructors	3200	3200	2200	3400	3400	2400	3700	3700	2700	4000	4000	3000	4200	4200	3200
	First 4 Years after Date of Appointment.			Second 4 Years after Date of Appointment.			After 6 Years from Date of Appointment.								
Assistant naval constructors	$ 2000	$ 2000	$ 1500	$ 2200	$ 2200	$ 1700	$ 2600	$ 2600	$ 1900						
	First 3 Years after Date of Appointment.			Second 3 Years after Date of Appointment.			Third 3 Years after Date of Appointment.			Fourth 3 Years after Date of Appointment.			After 12 Years from Date of Appointment.		
Warrant officers—	$	$	$	$	$	$	$	$	$	$	$	4	$	$	$
Boatswains, gunners, carpenters, sailmakers, pharmacists, and warrant machinists	1200	900	700	1300	1000	800	1400	1300	900	1600	1300	1000	1800	1600	1200
	At Sea.	Shore Duty.	On Leave or waiting Orders.												
Mates—	$	$	$												
Those in service 1st August 1894	1200	900	700												
Those appointed since	900	700	500												

All officers paid under this table are allowed 30 cents per day when attached to a sea-going vessel as a commutation for rations. Naval cadets are allowed this amount at all times.

TABLE III.—*Petty Officers, Enlisted Men, &c.—Navy.*

CLASSIFICATION AND PAY.

Chief Petty Officers.

Seaman Branch.	Monthly Pay.	Artificer Branch.	Monthly Pay.	Special Branch.	Monthly Pay.
	$		$		$
Chief masters-at-arms	65	Chief machinists	70	Chief yeomen	60
Chief boatswains' mates	50	Chief carpenters' mates	50	Hospital stewards	60
Chief gunners' mates	50	Chief electricians	60	Bandmasters	52
Chief gun captains	50				
Chief quartermasters	50				
		Petty Officers—First Class.			
Masters-at-arms, first class	40	Machinists, first class	55	First musicians	36
Boatswains' mates, first class	40	Boilermakers	60	Yeomen, first class	40
Gunners' mates, first class	40	Coppersmiths	50		
Gun captains, first class	40	Blacksmiths	50		
Quartermasters, first class	40	Plumbers and fitters	45		
Schoolmasters	40	Sailmakers' mates	40		
		Carpenters' mates, first class	40		
		Water tenders	40		
		Electricians, first class	50		
		Petty Officers—Second Class.			
Masters-at-arms, second class	35	Machinists, second class	40	Yeoman, second class	35
Boatswains' mates, second class	35	Oilers	37		
Gunners' mates, second class	35	Carpenters' mates, second class	35		
Gun captains, second class	35	Printers	35		
Quartermasters, second class	35	Electricians, second class	40		
		Petty Officers—Third Class.			
Masters-at-arms, third class	30	Carpenters' mates, third class	30	Yeomen, third class	30
Coxswains (1)	30	Painters	30	Hospital apprentices, first class	30
Gunners' mates, third class	30	Electricians, third class	30		
Quartermaster, third class	30				

TABLE III.—*Petty Officers, Enlisted Men, &c.—continued.*

Seaman Branch.	Monthly Pay.	Artificer Branch.	Monthly Pay.	Special Branch.	Monthly Pay.
		Seamen—First Class			
Seamen gunners	26	Firemen, first class	35	Musicians, first class	32
Seamen	24				
Apprentices, first class	21				
		Seamen—Second Class.			
Ordinary seamen	19	Firemen, second class	30	Musicians, second class	30
Apprentices, second class	15	Shipwrights	25	Buglers	30
		Sailmakers	25	Hospital apprentices	20
		Seamen—Third Class.			
Landsmen	16	Coal passers	22		
Apprentices, third class	9				
		Messmen Branch.			
Stewards to commanders-in-chief	45	Wardroom stewards	37	Ship's cooks, first class	35
Cooks to commanders-in-chief	40	Wardroom cooks	32	Ship's cooks, second class	30
Stewards to commandants	45	Steerage stewards	25	Ship's cooks, third class	25
Cooks to commandants	40	Steerage cooks	22	Ship's cooks, fourth class	20
Cabin stewards	37	Warrant officers' stewards	24	Mess attendants	16
Cabin cooks	32	Warrant officers' cooks	20		

Any man who has received an honourable discharge from his last term of enlistment, who re-enlists for a term of four years within four months from the date of his discharge, receives an increase of $1.36 per month to the pay prescribed for the rating in which he serves for each consecutive re-enlistment.

TABLE IV.—*Non-commissioned Officers, Musicians, and Privates.—Marine Corps.*

Grade.	First Enlistment, or first 5 Years.					First re-enlistment, or second 5 Years.	Second re-enlistment, or third 5 Years.	Third re-enlistment, or fourth 5 Years.	Fourth re-enlistment, or fifth 5 Years.
	First Year.	Second Year.	Third Year.	Fourth Year.	Fifth Year.				
	$	$	$	$	$	$	$	$	$
Sergeant-major	34	34	35	36	37	39.00	40	41.00	42
Quartermaster-sergeant	34	34	35	36	37	39.00	40	41.00	42
Drum major	25	25	26	27	28	30.00	31	32.00	33
Gunnery sergeant	35	35	36	37	38	40.00	41	42.00	43
First sergeant	25	25	26	27	28	30.00	31	32.00	33
Sergeant	18	18	19	20	21	23.00	24	25.00	26
Corporal	15	15	16	17	18	20.00	21	22.00	23
Drummer and trumpeter	13	13	14	15	16	18.00	19	20.00	21
Private	13	13	14	15	16	18.00	19	20.00	21
Leader of the band	125	125	125	125	125	137.50	150	162.50	175
Second leader of band	75	75	76	77	78	80.00	81	82.00	83
Musician, first class	60	60	60	60	60	60.00	60	60.00	60
Musician, second class	50	50	50	50	50	50.00	50	50.00	50

Matériel.

The incessant changes in *matériel* and its distribution render a comprehensive description of this subject of little more than ephemeral value. On 1st January 1901 there were 239 vessels of all classes on the navy list, and 67 more under construction.

TABLE A. *Completed Vessels—Modern Construction.*

7 1st class battleships	10,288 to 11,565 tons.
1 2nd ,, battleship	6,315 ,,
2 armoured cruisers	8,200 to 9,215 ,,
5 protected ,,	3,000 to 7,375 ,,
3 unprotected ,,	2,089 ,,
19 gunboats	839 to 1,710 ,,
6 monitors	3,990 to 6,060 ,,
1 harbour-defence ram	2,155 ,,
1 dynamite cruiser	929 ,,
20 torpedo boats	46 to 273 ,,
1 ,, boat (submarine)	73 ,,
76	

All of the above are of modern steel construction (except the monitors, which are of iron), the first commission of the oldest dating December 1885, and the great majority were first commissioned since 1890, and most built prior to 1890 have since been rebuilt. Next in order of practical efficiency are the converted vessels purchased prior to or during the Spanish war. Many are now in commission and may be retained in service indefinitely.

TABLE B. *Auxiliary Fighting Ships.*

5 converted cruisers	4260 to 6888 tons.
4 ,, yachts	806 to 2690 ,,
11 ,, ,,	302 to 786 ,,
8 ,, ,,	82 to 192 ,,
26 ,, tugs	150 to 840 ,,
54	

There are also 26 gunboats captured or purchased from Spain, varying in size from 42 to 1159 tons, and in characteristics from single-screw iron boats to twin-screw steel craft of late design and high efficiency.

TABLE C. *Auxiliaries.*

10 colliers	3085 to 7500 tons.
2 distilling ships	6100 to 6206 ,,
1 tank ,,	6200 ,,
1 hospital ,,	4700 ,,
5 supply ,,	2600 to 7000 ,,
1 marine transport	1400 ,,
15 unarmed tugs	192 to 450 ,,
41	

The following vessels of old construction are still seaworthy and efficient for their type, and many are in commission—

TABLE D. *Old Construction.*

8	single-turret iron monitors.
2	iron steam cruisers.
2	„ paddle gunboats.
7	wooden steam cruisers.
1	„ torpedo boat of 17 knots speed.
20	

TABLE E. *Inefficient.*

22 wooden sailing vessels, mostly unserviceable, except as receiving ships, &c.

TABLE F. *Under Construction.*

10	1st class battleships . . .	11,525 to 15,000 tons.
6	armoured cruisers	13,600 to 14,000 „
3	protected „	9,600 „
6	„ „	3,100 „
4	monitors	3,214 „
1	gunboat	
6	submarine boats . . .	120 „
1	torpedo craft	165 to 420 „
67		

United States naval vessels are, as a rule, built at private yards under contracts awarded after competition. The Government is not committed to any fixed policy or building programme. Each year the Secretary recommends certain new construction. The final action rests with Congress, which must appropriate money for the new ships before the construction can be commenced. Repairing and reconstruction are usually done at Government navy yards.

Distribution.

Ships in commission are distributed among five stations: (1) the North Atlantic, which includes the Atlantic coast of the United States, Central America, and South America as far as the Amazon, also the West Indies; (2) the South Atlantic, which includes the remainder of the Atlantic coast of South America and both coasts of South Africa; (3) the European, which comprises the coast of Europe, including the inland seas, and the North Atlantic coast of Africa; (4) the Asiatic station, comprising the coast of Asia, including the islands north of the equator, also the east coast of North Africa; (5) the Pacific station, comprising the Pacific coast of North and South America, and Australia and the adjacent islands lying south of the equator. Each station is commanded by a flag officer, and the number of ships under the command varies according to circumstances. Ships in commission on special service, such as training, gunnery, surveying ships, &c., are not attached to stations. The shore stations of the navy are enumerated in the article on DOCKYARDS. (W. T. S.)

Admiralty, Cinque Ports Court of.—The Court of Admiralty for the Cinque Ports exercises a co-ordinate but not exclusive Admiralty jurisdiction over persons and things found within the territory of the Cinque Ports. The limits of its jurisdiction were declared at an inquisition taken at the Court of Admiralty, held by the seaside at Dover in 1682, to extend from Shore Beacon in Essex to Redcliff, near Seaford, in Sussex; and with regard to salvage, they comprise all the sea between Seaford in Sussex to a point five miles off Cape Grisnez on the coast of France, and the coast of Essex. An older inquisition of 1526 is given by Mr Marsden in his *Select Pleas of the Court of Admiralty*, II. xxx. The court is an ancient one. The judge sits as the official and commissary of the Lord Warden, just as the judge of the High Court of Admiralty sat as the official and commissary of the Lord High Admiral. And, as the office of Lord Warden is more ancient than the office of Lord High Admiral (*The Lord Warden* v. *King in his office of Admiralty*, 1831, 2 Hagg. Admy. Rep. 438), it is probable that the Cinque Ports Court is the more ancient of the two.

The jurisdiction of the court has been, except in one matter of mere antiquarian curiosity, unaffected by statute. It exercises only, therefore, such jurisdiction as the High Court of Admiralty exercised, apart from the restraining statutes, 13 Ric. II. c. 5, 15 Ric. II. c. 3, and the enabling statutes, 3 and 4 Vict. c. 65, and 24 Vict. c. 10. Cases of collision have been tried in it (the "Vivid," 1 *Asp. Maritime Law Cases*, 601). But salvage cases (the "Clarisse," *Swabey*, 129; the "Marie," *Law. Rep.* 7 *P.D.* 203) are the principal cases now tried. It has no prize jurisdiction. The one case in which jurisdiction has been given to it by statute is to enforce forfeitures under 5 Eliz. c. 5.

Mr Arthur Cohen, K.C., is the present judge. His predecessor was Dr (afterwards the Right Hon. Sir Robert Joseph) Phillimore, who succeeded his father in the same office, and was judge from 1855 to 1875. As Sir Robert Phillimore was also the last judge of the High Court of Admiralty, from 1867 (the date of his appointment to the High Court) to 1875, the two offices were probably for the first time in history held by the same person. The appointment is by the Lord Warden. Dr Phillimore's patent had a grant of the "place or office of judge official and commissary of the Court of Admiralty of the Cinque Ports, and their members and appurtenances, and to be assistant to my lieutenant of Dover castle in all such affairs and business concerning the said Court of Admiralty wherein yourself and assistance shall be requisite and necessary." Of old the court sat sometimes at Sandwich, sometimes at other ports. But the regular place for the sitting of the court has for a long time been, and still is, the aisle of St James's Church, Dover. For convenience the judge often sits at the Royal Courts of Justice. The office of marshal in the High Court is represented in this court by a serjeant, who also bears a silver oar. There is a registrar, as in the High Court. The appeal is to the queen in council, and is heard by the judicial committee. The court can hear appeals from the Cinque Ports salvage commissioners, such appeals being final (1 and 2 Geo. IV. c. 76, § 4). Actions may be transferred to it, and appeals made to it, from the county courts in all cases arising within the jurisdiction of the Cinque Ports as defined by that Act. At the solemn installation of the Lord Warden the judge as the next principal officer installs him.

The Cinque Ports from the earliest times claimed to be exempt from the jurisdiction of the admiral of England. Their early charters do not, like those of Bristol and other seaports, express this exemption in terms. It seems to have been derived from the general words of the charters which preserve their liberties and privileges.

The Lord Warden's claim to prize was raised in, but not finally decided by, the High Court of Admiralty in the "Ooster Ems," 1 *C. Rob.* 284, 1783.

See BOYS. *Sandwich and Cinque Ports.*—KNOCKER. *Grand Court of Shepway*, 1862. (W. G. F. P.)

Admiralty, High Court of.—The High Court of Admiralty was the court of the deputy or lieutenant of the admiral. It is supposed in the *Black Book of the Admiralty* to have been founded in the reign of Edward I.; but it would appear, from the learned discussion of Mr Marsden, that it was established as a civil court by Edward III. in the year 1360; the power of the admiral to determine matters of discipline in the fleet, and possibly questions of piracy and prize, being somewhat earlier. Even then the court as such took no formal shape; but the various admirals began to receive in their patents express grants of jurisdiction with powers to appoint lieutenants or deputies. At first there were separate admirals or rear-admirals of the north, south, and west, each with deputies and courts. A list of them was collected by Sir H. Spelman. These were merged in or absorbed by one high court early in the 15th century. Sir Thomas Beaufort, afterwards earl of Dorset and duke of Exeter (appointed admiral of the fleet, 9 Henry IV., and admiral of England, Ireland, and Aquitaine 1412, which latter office he held till his death in 1417), certainly had a court, with a marshal and other officers, and forms of legal process—mandates, warrants, citations, compulsories, proxies, &c. For the subject matters of the ancient Admiralty jurisdiction it is usual to refer to the inquisition of Queenborough in 1375. Complaints of encroachment of jurisdiction by the Admiralty courts led to the restraining Acts, 13 Ric. II. c. 5, 15 Ric. II. c. 3, and 2 Hen. IV. c. 11.

Jurisdiction.

The original object of the institution of the courts or court seems to have been to prevent or punish piracy and other crimes upon the narrow seas and to deal with questions of prize; but civil jurisdiction soon followed. The jurisdiction in criminal matters was transferred by 28 Hen. VIII. c. 15 to the admiral or his deputy and three or four other substantial persons appointed by the Lord Chancellor, who were to proceed according to the course of the common law. By 4 and 5 Will. IV. c. 36, cognizance of crimes committed within the jurisdiction of the Admiralty was given to the central criminal court. By 7 and 8 Vict. c. 2, it has been also given to the justices of assize; and crimes done within the jurisdiction of the Admiralty are now tried as crimes committed within the body of a county. See also the Criminal Law Consolidation Acts of 24 and 25 Victoria.

From the time of Henry IV. the only legislation affecting the civil jurisdiction of the High Court of Admiralty till the time of Queen Victoria is to be found in § 10 of 32 Hen. VIII. c. 14, enabling the admiral or his lieutenant to decide on certain complaints of freighters against shipmasters for delay in sailing, and § 34 of 5 Eliz. c. 5, giving the Lord High Admiral of England, the Lord Warden of the Cinque Ports, their lieutenants and judges, co-ordinate power with other judges to enforce forfeitures under that Act—a very curious and miscellaneous statute called "An Act for the Maintenance of the Navy."

In the Act 25 Hen. VIII. c. 19, with regard to ecclesiastical appeals from the courts of the archbishops to the Crown, it is provided that the appeal shall be to the king in Chancery, "and that upon every such appeal a commission shall be directed under the great seal to such persons as shall be named by the king's highness, his heirs or successors, like as in cases of appeal from the Admiralty Court." The appeal to these "persons," called delegates, continued until it was transferred first to the Privy Council and then to the judicial committee of the Privy Council by the statutes 2 and 3 Will. IV. c. 92, and 3 and 4 Will. IV. c. 41.

The early jurisdiction of the court appears to have been exercised very much under the same procedure as that used by the Courts of Common Law. Juries are mentioned, sometimes of the county and sometimes of the county and merchants. But the connexion with foreign parts led to the gradual introduction of a procedure resembling that coming into use on the Continent and based on the Roman civil law. The statute 28 Hen. VIII. c. 15, states the objection to this application of the civil law to the trial of criminal cases with much force: "After the course of the civil laws, the nature whereof is that before any judgment of death can be given against the offenders, either they must plainly confess their offences (which they will never do without torture or pain), or else their offences be so plainly and directly proved by witness indifferent such as saw their offences committed, which cannot be gotten but by chance at few times."

Restraining Acts.

The material enactments of the restraining statutes were as follows:—13 Ric. II. c. 5 provided that "the admirals and their deputies shall not meddle from henceforth of anything done within the realm, but only of a thing done upon the sea, as it hath been used in the time of the noble prince king Edward, grandfather of our lord the king that now is." 15 Ric. II. c. 3 provided, that "of all manner of contracts, pleas, and quarrels, and other things rising within the bodies of the counties as well by land as by water, and also of wreck of the sea, the admiral's court shall have no manner of cognizance, power, nor jurisdiction; but all such manner of contracts, pleas, and quarrels, and all other things rising within the bodies of counties, as well by land as by water, as afore, and also wreck of the sea, shall be tried, determined, discussed, and remedied by the laws of the land, and not before nor by the admiral, nor his lieutenant in any wise. Nevertheless, of the death of a man, and of a maihem done in great ships, being and hovering in the main stream of great rivers, only beneath the [bridges] of the same rivers [nigh] to the sea, and in none other places of the same rivers, the admiral shall have cognizance, and also to arrest ships in the great flotes for the great voyages of the king and of the realm; saving always to the king all manner of forfeitures and profits thereof coming; and he shall have also jurisdiction upon the said flotes, during the said voyages only; saving always to the lords, cities, and boroughs, their liberties and franchises." 2 Hen. IV. c. 11 adds nothing by way of definition or restriction, but merely gives additional remedies against encroachments, providing heavy fines for those who improperly sue in the court, and those officials of the court who improperly assert jurisdiction. It was repealed by 24 Vict. c. 10. The statutes of Richard, except the enabling part of the second, were repealed by 42 and 43 Vict. c. 59. The formation of a High Court of Justice rendered them obsolete.

In the reign of James I. the chronic controversies between the Courts of Common Law and the Admiralty Court as to the limits of their respective jurisdictions reached an acute stage. We find the records of it in the second volume of Mr Marsden's *Select Pleas in the Court of Admiralty*, and in Lord Coke's writings: *Reports*, part xiii. 51; *Institutes*, part iv. chap. 22. In this latter passage Lord Coke records how, notwithstanding an agreement asserted to have been made in 1575 between the justices of the King's Bench and the judge of the Admiralty, the judges of the Common Law Courts successfully maintained their right to prohibit suits in Admiralty upon contracts made on shore, or within havens, or creeks, or tidal rivers, if the waters were within the body of any county, wheresoever such contracts were broken, for torts committed within the body of a county, whether on land or water, and for contracts made in parts beyond the seas. It is due to the memory of the judges of Lord Coke's time to say that, at any rate as regards contracts made *in partibus transmarinis*, the same rule appears to have been applied at least as early as 36 Hen. VIII., the judges then holding that "for actions transitory abroad action may lie at common law."

All the while, however, the patents of the Admiralty

Judge's patent.

judge purported to confer on him a far ampler jurisdiction than the jealousy of the other courts would concede to him. The patent of the last judge of the court, Sir Robert Joseph Phillimore, dated 23rd August 1867, styles him "Lieut. Off^{l}. Princ^{l}. and Commissary Gen^{l}. and Special in our High Court of Admiralty of Eng. and President and Judge of the same," and gives to him power to take cognizance of "all causes, civil and maritime, also all contracts, complaints, offences or suspected offences, crimes, pleas, debts, exchanges, accounts, policies of assurance, loading of ships, and all other matters and contracts which relate to freight due for the use of ships, transportation, money, or bottomry; also all suits civil and maritime between merchants or between proprietors of ships and other vessels for matters in, upon, or by the sea, or public streams, or fresh-water ports, rivers, nooks, and places overflown whatsoever within the ebbing and flowing of the sea and high-water mark, or upon any of the shores or banks adjacent from any of the first bridges towards the sea through England and Ireland and the dominions thereof, or elsewhere beyond the seas." Power is also given to hear appeals from vice-admirals; also "to arrest . . . according to the civil laws and ancient customs of our high court . . . all ships, persons, things, goods, wares, and merchandise"; also "to enquire by the oaths of honest and lawful men . . . of all . . . things which . . . ought to be enquired after, and to mulct, arrest, punish, chastise, and reform"; also "to preserve the public streams of our Admiralty as well for the preservation of our royal navy, and of the fleets and vessels of our kingdom . . . as of whatsoever fishes increasing in the rivers"; also "to reform nets too straight and other unlawful engines and instruments whatsoever for the catching of fishes"; also to take cognizance "of the wreck of the sea . . . and of the death, drowning, and view of dead bodies," and the conservation of the statutes concerning wreck of the sea and the office of coroner [3 and 4 Edw. I.], and concerning pillages [27 Edw. III.], and "the cognizance of mayhem" within the ebb and flow of the tide; all in as ample manner and form as they were enjoyed by Dr David Lewis [judge from 1558-84], Sir Julius Cæsar, and the other judges in order (22 in all) before Sir Robert Phillimore. This form of patent differs in but few respects from the earlier Latin patents—*tempore* Henry VIII.—except that they have a clause *non obstantibus statutis.*

Modern progress.

As has been said, however, the contention of the Common Law judges prevailed, and the Admiralty Court (except during a temporary revival under Cromwell) sank into comparative insignificance during the 17th century. The great maritime wars of the 18th century gave scope to the exercise of its prize jurisdiction; and its international importance as a prize court in the latter half of the 18th and the first part of the 19th centuries is a matter of common historical knowledge.

There were other great judges; but Sir William Scott, afterwards Lord Stowell, is the most famous. Before his time there were no reports of admiralty cases, except Hay and Marriott's prize decisions. But from his time onwards there has been a continuous stream of Admiralty Reports, and we begin to find important cases decided on the instance as well as on the prize side.

In the reign of Queen Victoria, two enabling statutes, 3 and 4 Vict. c. 65 and 24 Vict. c. 10, were passed and greatly enlarged the jurisdiction of the court. The manner in which these statutes were administered by Dr. Lushington and Sir R. Phillimore, whose tenure of office covered the whole period of the Queen's reign till the creation of the High Court of Justice, the valuable assistance rendered by the nautical assessors from the Trinity House, the great increase of shipping, especially of steam shipping, and the number and gravity of cases of collision, salvage, and damage to cargo, restored the activity of the court and made it one of the most important tribunals of the country. In 1875, by the operation of the Judicature Acts of 1873 and 1875, the High Court of Admiralty was with the other great courts of England formed into the High Court of Justice. The principal officers of the court in subordination to the judge were the registrar (an office which always points to a connexion with canon or civil law), and the marshal, who acted as the maritime sheriff, having for his baton of office a silver oar. The assistance of the Trinity Masters, which has been already mentioned, was provided for in the charter of incorporation of the Trinity House. These officers and their assistance have been preserved in the High Court of Justice.

See Sir Travers Twiss. *Black Book of the Admiralty.* Rolls series.—Maasden. *Select Pleas in the Court of Admiralty,* published by the Selden Society.—Godolphin. *View of the Admiral Jurisdiction.* (W. G. F. P.)

Admiralty Jurisdiction.—The courts by which, as far as we know, Admiralty jurisdiction in civil matters was first exercised were the following. In and throughout England the courts of the several admirals soon combined into one High Court of Admiralty. Within the territories of the Cinque Ports the Court of Admiralty of the Cinque Ports exercised a co-ordinate jurisdiction. In certain towns and places there were local courts of Vice-Admiralty. In Scotland there existed the Scottish High Court of Admiralty, in Ireland the Irish High Court of Admiralty. Of these courts that of the Cinque Ports alone remains untouched. The Scottish court was absorbed, and its jurisdiction given to the Court of Session by 11 Geo. IV. and 1 Will. IV. c. 69—not, however, till a decision given by it and the appeal therefrom to the House of Lords had established a remarkable rule of Admiralty law in cases of collision (*Hay* v. *Le Neve*, 1824, 2 Shaw, *Sc. App. Cas.* 395). The local Vice-Admiralty Courts in England had ceased to do much work when they were abolished by the Municipal Corporations Act, 1835; the High Court became, with the other superior courts, a component part of the High Court of Justice by virtue of the Judicature Acts, 1873 and 1875. And the Irish court has in like manner become a part of the High Court of Justice in Ireland by the Judicature Act for that country.

Vice-Admiralty Courts.

As England first, and Great Britain afterwards, acquired colonies and possessions beyond seas, Vice-Admiralty Courts were established. The earliest known was that in Jamaica, established in the year 1662. Some Vice-Admiralty Courts which were created for prize purposes in the last century were suffered to expire after 1815. In the year 1863, when the Act regulating the Vice-Admiralty Courts was passed, there were Vice-Admiralty Courts at Antigua, Bahamas, Barbadoes, Bermuda, British Columbia, British Guiana, British Honduras, Cape of Good Hope, Ceylon, Dominica, Falkland Islands, Gambia River, Gibraltar, Gold Coast, Grenada, Hong Kong, Jamaica, Labnan, Lagos, Lower Canada (otherwise Quebec), Malta, Mauritius, Montserrat, Natal, Nevis, New Brunswick, Newfoundland, New South Wales, New Zealand, Nova Scotia (otherwise Halifax), Prince Edward Island, Queensland, Saint Christopher, Saint Helena, Saint Lucia, Saint Vincent, Sierra Leone, South Australia, Tasmania, Tobago, Trinidad, Vanconver's Island, Victoria, Virgin Islands (otherwise Tortola), Western Australia. By the Act of 1867 one for the Straits Settlements was added. These courts have been regulated from time to time by the following statutes:

2 Will. IV. c. 51, 26 Vict. c. 24 already cited, and 30 and 31 Vict. c. 45. In 1890 the Colonial Courts of Admiralty Act provided that, except in the colonies of New South Wales, Victoria, Saint Helena, and British Honduras, Vice-Admiralty Courts should be abolished, and a substitution made of Colonial Courts of Admiralty. There is power, however, reserved to the Crown to erect through the Admiralty in any British possession any Vice-Admiralty Court, except in India or any British possession having a representative legislature. No Vice-Admiralty Court so established can exercise any jurisdiction except for some purpose relating to prize, the royal navy, the slave trade, foreign enlistment, Pacific Islanders' protection, and questions relating to treaties or conventions on international law. Vice-Admiralty Courts exercised all usual Admiralty jurisdiction, and in addition a certain revenue jurisdiction, and jurisdiction over matters of slave trade and prize (royal navy) and under the Pacific Islanders' Protection Act. The appeal from Vice-Admiralty Courts used to lie to the High Court of Admiralty of England, but has been transferred to the King in Council.

County Courts.

Modern statutes have given Admiralty jurisdiction to the county courts in the following matters:—Salvage, where the value of the salved property does not exceed £1000, or the claim for reward £300; towage, necessaries, and wages, where the claim does not exceed £150; claims for damage to cargo, or by collision, up to £300 (and for sums above these prescribed limits by agreement between the parties); and claims arising out of breaches of charter parties and other contracts for carriages of goods in foreign ships, or torts in respect thereof up to £300. This jurisdiction is restricted to subjects over which jurisdiction was possessed by the High Court of Admiralty at the time when the first of these Acts was passed, except as regards the last branch of it (The "Aline," 1880, 5 Ex. Div. 227; *Reg.* v. *Judge of City of London Court*, 1892, 1 Q.B. 272). In analogy with the county court Admiralty jurisdiction created in England, a limited Admiralty jurisdiction has been given in Ireland to the recorders of certain boroughs and the chairmen of certain Quarter Sessions; and in salvage cases, where a county court in England would have jurisdiction, magistrates, recorders, and chairmen of Quarter Sessions may have jurisdiction as official arbitrators (57 and 58 Vict. c. 60, § 547). In Scotland, Admiralty suits in cases not exceeding the value of £25 are exclusively tried in the Sheriff's Court; while over that limit the Sheriff's Court and the Court of Session have concurrent jurisdiction.

By the Act 1 and 2 Geo. IV. c. 76, an arbitral jurisdiction in cases of salvage was given to certain commissioners of the Cinque Ports.

Appeals.

The appeal from county courts and commissioners is to the High Court of Justice, and is exercised by a divisional court of the Probate, Divorce, and Admiralty Division. In cases arising within the Cinque Ports there is an optional appeal to the Admiralty Court of the Cinque Ports. The appeal from the High Court of Justice is in ordinary Admiralty matters, as in others, to the Court of Appeal, and from thence to the House of Lords. But it is specially provided by the Judicature Act 1891, as it was by the Prize Act 1864, that the appeal in prize cases shall be to the Sovereign in Council.

Civil jurisdiction.

The unfortunate provisions of the Legislature, giving to the jurisdiction of county courts different money limits in Admiralty, Equity, and Common Law cases, make the distinction between cases coming under the Admiralty jurisdiction and other civil cases of practical moment in those courts. Arguments full of learning and research have been addressed to the courts, and weighty decisions have been given, upon questions which would never have arisen if the county courts had not a larger money area of jurisdiction in Admiralty cases than they have in other matters (*Reg.* v. *Judge of City of London Court*, 1892, 1 Q.B. 273; The "Zeta," 1893, *App. Cas.* 468). But as regards the high courts, whether in England, Scotland, or Ireland, it is not now necessary to distinguish their civil Admiralty jurisdiction from their ordinary civil jurisdiction, except for the purpose of seeing whether there can or cannot be process *in rem*. Not that every Admiralty action can of right be brought *in rem*, but that no process *in rem* lies at the suit of a subject unless it be for a matter of Admiralty jurisdiction—one, for instance, that could in England have been tried in the High Court of Admiralty. Now these matters of Admiralty jurisdiction with process *in rem* range themselves under four primary and four supplementary heads. The four primary are damage, salvage, bottomry, wages; and the four supplementary are extensions due to one or other of the statutes 3 and 4 Vict. c. 65, and 24 Vict. c. 10. They are damage to cargo carried in a ship, necessaries supplied to a ship, mortgage of ship, and master's claim for wages and disbursements on account of a ship. In all these cases, primary and secondary, the process of which a plaintiff can avail himself for redress, may be either *in personam* as in other civil suits, or by arrest of the ship, and, in cases of salvage and bottomry, the cargo. Whenever, also, the ship can be arrested, any freight due can also be attached, by arrest of the cargo to the extent only of the freight which it has to pay. For the purpose of ascertaining whether or not process *in rem* would lie, there have been distinctions as nice, and the line of Admiralty jurisdiction has been drawn as carefully, as in the cases of the Admiralty jurisdiction of the county courts (The "Theta," 1894, *Prob.* 280; The "Gas Float Whittoo," 1897, *App. Cas.* 337). There have been similar questions raised in the United States, from *De Lovio* v. *Boit* (1815, 2 Gallison, 398), and *Ramsay* v. *Allegre* (1827, 12 Wheaton, 611), down to the quite modern cases which will be found quoted in the arguments and judgments in the "Float Whitton."

Disciplinary.

The disciplinary jurisdiction at one time exercised by the Admiralty Court, over both the royal navy and merchant vessels, may be said to be obsolete in time of peace, the last remnant of it being suits against merchantmen for flying flags appropriate to men-of-war (The "Minerva," 1800, 3 C. Rob. 34), a matter now more effectively provided against by the Merchant Shipping Act, 1894. In time of war, however, it was exercised in some instances as long as the Admiralty Court lasted, and is now in consequence exercisable by the High Court of Justice (see *Prize* below). It was, perhaps, in consequence of its ancient disciplinary jurisdiction that the Admiralty Court was made, and the High Court of Justice now is, the court to enforce certain portions of the Foreign Enlistment Act, 1870.

Finally, appeals from decisions of courts of enquiry, under the Merchant Shipping Act, cancelling or suspending the certificates of officers in the merchant service, may be made to the Probate, Divorce, and Admiralty Division of the High Court of Justice.

Criminal cases.

The Admiralty jurisdiction in criminal matters extends over all crimes committed on board British ships on sea or tidal waters, even though such tidal waters be well within foreign territory (*Reg.* v. *Anderson*, 1868, L.R. 1 C.C.R. 161), but not over crimes committed on board foreign vessels upon the high seas (*Reg.* v. *Serva*, 1845, 1 Denison C.C., 104). Whether it extended over crimes committed on foreign ships within territorial waters of the United Kingdom, and whether a zone of three miles round the shores of the United Kingdom was for such purpose territorial water, were the great questions raised in *Reg.* v. *Keyn* (The "Franconia," L.R. 2 Ex. Div. 126), and decided in the negative by the majority of the judges, rightly, as the writer of this article respectfully thinks. Since then, however, the Legislature has brought these waters within the jurisdiction of the Admiralty by 41 and 42 Vict. c. 73. Section 2 runs as follows: "An offence committed by a person, whether he is or is not a British subject, on the open sea within the territorial waters of British dominions, is an offence within the jurisdiction of the admiral, although it may have been committed on board or by means of a foreign ship, and the person who committed such offence may be arrested, tried, and punished accordingly." By § 7 the "jurisdiction of the admiral" is defined as "including the jurisdiction of the Admiralty of England or Ireland, or either of such jurisdictions as used in any Act of Parliament; and for the purpose of arresting any person charged with an offence declared by this Act to be within the jurisdiction of the admiral, the territorial waters adjacent to the United Kingdom, or any other part of Her Majesty's dominions, shall be deemed to be within the jurisdiction of any judge, magistrate, or officer." And "territorial waters of Her Majesty's dominions" are defined as "in reference to the sea, meaning such part of the sea adjacent to the coast of the United Kingdom, or the coast of some other part of Her Majesty's dominions, as is deemed by international law to be within the territorial sovereignty of Her Majesty; and for the purpose of any offence declared by this Act to be within the jurisdiction of the admiral, any part of the open sea within one marine league of the coast, measured from low-water mark, shall be deemed to be open sea within the territorial waters of Her Majesty's dominions." As to those portions of the sea and tidal waters which, by reason of their partially land-locked positions, are deemed to be in the body of a county, there is not Admiralty jurisdiction, but crimes are tried as if they were committed on land within the same county.

Pirates, whatever flag they pretended to fly, were, from 1360 onwards, wherever their crimes were committed, subject to the Admiralty jurisdiction. The criminal jurisdiction of the Admiralty was first exercised by the High Court of Admiralty; and then, by virtue of 28 Hen. VIII. c. 15, transferred to commissioners appointed under the great seal, among whom were to be the admiral or admirals, his or their deputies. Admiralty sessions were held for this purpose till 1834. Admiralty criminal jurisdiction is now, by virtue of the series of statutes 39 Geo. III. c. 37, 4 and 5 Will. IV. c. 36, 7 and 8 Vict. c. 2, and the criminal law consolidation Acts passed in 24 and 25 Vict. c. 1, exercised by the Central Criminal Court and by the ordinary courts of assize. Special provision for trial in the colonies of offences committed at sea has been made by 11 and 12 Will. III. c. 7, 46 Geo. III. c. 54, and 12 and 13 Vict. c. 96.

Prize.

The Admiralty Court had jurisdiction in matters of prize from very early times; and although since the middle of the 17th century the *instance*, or ordinary civil jurisdiction of the court, has been kept distinct from the *prize* jurisdiction, they were originally both administered and regarded as being within the ordinary jurisdiction of the Lord High Admiral. The early records of the Admiralty show that the origin of the prize jurisdiction is to be traced to the power given to the court of the admiral to try cases of piracy and "spoil," *i.e.*, captures of foreign ships by English ships. The earliest recorded case of spoil tried before the admiral is in 1357, when the goods of a Portuguese subject, taken at sea by Englishmen from a French ship which had previously spoiled a Portuguese, were awarded by the admiral as good prize to the English captors; and Edward III. in a letter to the king of Portugal answering a complaint on the subject gives the admiral's decision as a reason for refusing their restoration. During the 16th century a very large part of the business of the Admiralty Court related to spoil and piracy, and the Privy Council often directed the judge of the court how to deal with the spoil cases, with regard to which foreigners who had suffered from attacks by English ships made petition for redress to the admiral or the council. The spoil suit at this time (*causa spolii*) was a civil proceeding resulting in a decree *absolutoria*, dismissing the defendant, or *condemnatoria*, ordering restoration to be made by him. In 1585 the patent of Howard, the Lord High Admiral, authorized him to issue letters of reprisal against Spain; and an Order in Council regulating the conduct of those to whom such letters were issued, provided by an additional article (1589) that all prizes were to be brought in without breaking of bulk for adjudication by the Admiralty Court. The court was also resorted to at this time by captors, sailing under commissions granted by the allies of England, such as the king of France and the Dutch. About the middle of the 17th century separate sittings of the Court for Instance and Prize business began, perhaps because of the conflicting claims to *droits* of Charles II. and the duke of York as Lord High Admiral; and privateering under royal commission took the place of the former irregular "spoiling." The account which Lord Mansfield gave of the records of the Admiralty Court, that there were no prize act books earlier than 1641, or prize sentences earlier than 1648, and that before 1690 the records were in confusion, must be qualified by the fact that there are in existence prize sentences (on paper, not parchment) as early as 1589.

Although the courts of Common Law hardly ever seem to have interfered with or disputed the Admiralty prize jurisdiction, its exclusive nature was not finally admitted till 1782; but long previously royal ordinances (1512, 1602) and statutes (13 Car. II. c. 9, giving an alternative of commissioners, 22 and 23 Car. II. c. 11, 6 Anne, c. 13) had given the Admiralty Court the only express jurisdiction over prize. The same statute of Anne, and 13 Geo. II. c. 4, and 17 Geo. II. c. 24, give prize jurisdiction to any Court of Admiralty, and the Courts of Admiralty for the colonies and plantations in North America.

It has been a disputed question whether the prize jurisdiction of the court was inherent, *i.e.*, coming within the powers given by the general patent of the judge, in which no express mention of it is made, or whether it required a special commission. Upon this subject the judgment of Lord Mansfield in *Lindo* v. *Rodney* (1782, Dougl. 612), the judgment of Mr Justice Story in *De Lovio* v. *Boit* (1815, 2 Gallison, 398), and Mr Marsden's *Select Pleas of the Court of Admiralty* (introduction), may be consulted. But the settled practice now and for a long time past has been for a special commission and warrant to be issued for this purpose. In connexion with this it is observable that in 1793 the Admiralty Court of Ireland claimed to exercise prize jurisdiction under its general patent; and it is said to have been the opinion of Sir W. Wynne that the Admiralty of Scotland had a similar right (Brown, *Civil Law of Admiralty*, vol. ii. 211, 212). Any jurisdiction of the Scottish Admiralty Court over prize of war was transferred to the English court by 6 Geo. IV. c. 120, § 57. As to the Irish court, by the Act of Union it was provided that there should remain in Ireland an Instance Court of Admiralty for the determination of causes civil and maritime only.

In 1864 the constitution and procedure of prize courts, which had until then been prescribed by occasional Acts passed for each war as it arose, were for the first time made permanent by the Naval Prize Act, by which the High Court of Admiralty and every Admiralty or Vice-Admiralty Court, or any other court exercising admiralty jurisdiction in British dominions, if for the time being authorised to exercise prize jurisdiction, were made prize courts. The High Court of Admiralty was given jurisdiction throughout British dominions as a prize court, and, as such, power to enforce any order of a Vice-Admiralty prize court and the judicial committee of the Privy Council in prize appeals—this power *mutatis mutandis* being also given to Vice-Admiralty prize courts. An appeal was given from any prize court to the Sovereign in Council. Prize courts were given jurisdiction in cases of captures made in a land expedition or an expedition made conjointly with allied forces, and power to give prize salvage on recaptured ships and prize bounty; and a form of procedure was prescribed. The High Court was also given exclusive jurisdiction as a prize court over questions of ransom and petitions of right in prize cases, and power to punish masters of ships under convoy disobeying orders or deserting convoy. By the Naval Discipline Act, 1866, power to award damages to convoyed ships exposed to danger by the fault of the officer in charge of the convoy was also given to the High Court. Under other statutes it had power to try questions of booty of war when referred to it by the Crown, in the same way as prize causes, and claims of King's ships for salvage on recaptures from pirates, which could be condemned as *droits* of Admiralty, subject to the owner's right to receive them on paying one-eighth of the value, and also power to seize and restore prizes captured by belligerents in violation of British neutrality, or by a ship equipped in British ports contrary to British obligations of neutrality.

All jurisdiction of the High Court of Admiralty has since passed to the High Court of Justice, which is made a prize court under the Naval Prize Act, with all the powers of the Admiralty Court in that respect; and all prize causes and matters within the jurisdiction of that court as a prize court are assigned to the Probate, Divorce, and Admiralty Division; and an appeal from it as a prize court lies only to the King in Council (Judicature Acts, 1873 and 1891).

By an Act of 1894 further provision is made for the constitution of prize courts in British possessions. A commission, warrant, or instruction from the Crown or the Admiralty may be issued at any time, even in peace; and upon such issue, subject to instructions from the Crown, the vice-admiral of the possessions on being satisfied by information from a Secretary of State that war has broken out between Great Britain and a foreign State, may make proclamation to that effect, and the commission or warrant comes into effect. The commission or warrant may authorize a Vice-Admiralty Court or Colonial Court of Admiralty to act as a prize court, or establish a Vice-Admiralty Court for that purpose, and may be revoked or altered at any time. The court is authorized to act as a prize court during the war, and shall after its conclusion continue to act as such, and finally dispose of all matters and things arising during the war, including all penalties and forfeitures incurred therein. Rules of court may also be made by Order in Council for regulating, subject to the Naval Prize Act, the procedure and practice of prize courts under that Act, the duties and conduct of their officers and practitioners, and the fees and costs therein (57 and 58 Vict. c. 39, §§ 2, 3). This latter power has been exercised; and prize rules for the High Court of Justice and the Vice-Admiralty prize courts were framed in 1898 (Statutory Rules and Orders, 1898).

United States.—Jurisdiction in admiralty proceedings is exclusively vested in the federal courts of the United States. The remedy in admiralty is much more extensive than in England (*Insurance Company* v. *Dunham*, 11 Wallace's *Reports*, 1). Where the common law affords another mode of action, either can be pursued. The term "admiralty" covers both civil and criminal causes, and is not limited to strictly maritime affairs. The great lakes and rivers are subject to it equally with the sea (*United States Revised Statutes*, title LXX. chap. iii.; 26 *Statutes at Large*, 424). The test is not whether the waters are tidal, but whether they are navigable. A jury may be demanded in certain civil causes (see *Revised Statutes*, 566). The States cannot create maritime liens, nor can State courts enforce them. States can create liens of a non-maritime character on vessels, and the United States Courts of Admiralty may enforce them by *in rem* proceedings (The "Glide," 167 *United States Reports*, 606). A merchantman at sea occupies the position, as to property rights, of a floating portion of the territory of the State to which he belongs (*Crapo* v. *Kelly*, 16 Wallace's *Reports*, 610). The English International Rules of 1880 were adopted by the United States in 1885. In the United States, waters are held to be within the body of a county though not so land-locked that objects can be distinctly seen by one looking from one shore to the other with the naked eye (*Manchester* v. *Massachusetts*, 139 *United States Reports*, 240, 263). The District Court of the United States is its court of admiralty of original jurisdiction.

Authorities.—Marsden's *Select Pleas of the Court of Admiralty*, Selden Society, London, 1892 and 1897.—Zouch, *Jurisdiction of the Admiralty of England asserted*.—Robinson, *Collectanea Maritima*.—Brown, *Admiralty*.—Edwardes, *Admiralty*.—Phillimore, *International Law*, vol. iii.

(W. G. F. P.; S. E. B.)

Admiralty Islands. See New Guinea.

Adoni, a town of British India, in the Bellary district of Madras, 307 miles from Madras by rail, has manufactures of carpets, silk, and cotton goods, and three factories for ginning and pressing cotton. The hill-fort above, now in ruins, was an important seat of government in Mahommedan times, and is frequently mentioned in the wars of the 18th century. Population, about 26,000.

Adowa, or Adua. See Abyssinia.

Adrar. See Sahara.

Adrian, a city of Michigan, U.S.A., the capital of Lenawee county, situated on the south branch of Raisin river, in the southern part of the state, 30 miles north-west of Toledo, at an altitude of 810 feet. Its plan is somewhat irregular; it is divided into five wards; and it is entered by three railways. Adrian college is a well-known Methodist institution. The population in 1880 was 7849; in 1890 it was 8756, and in 1900 it was 9654.

Adrianople, a city of European Turkey, 141 miles W.N.W. of Constantinople. It suffered heavily by the Russian occupation in 1878, not only through the dislocation of its commerce, but also through the extensive emigration to Asia Minor of the Mahommedan lower classes—a movement which so diminished the labour power of the province that agriculture, its staple industry, was paralysed, and a large area of land fell out of cultivation. This mischief was partially remedied after the annexation (1885) of Eastern Rumelia to Bulgaria, when a large proportion of the Mahommedan inhabitants of the detached province came to settle in and around Adrianople; but this advantage was more than counterbalanced by other consequences of the territorial change. In 1892, when the last census was taken, the population numbered 85,780. Little reliance, however, can be placed on a Turkish census, the figures of which are always exaggerated. The most competent residents estimate the present (1901) population at between 66,000 and 70,000. In point of structure Adrianople is thoroughly oriental—a mass of mean, irregular wooden buildings, threaded by narrow tortuous streets, with a sprinkling of edifices of superior class. Of these the most important are the Idadieh school, the school of arts and crafts, the Jewish communal school; the Greek college, Zappeion; the Imperial Ottoman Bank and Tobacco Regie, a fire-tower, a theatre, palaces for the prefect of the city, the administrative staff of the 2nd Army Corps, and the defence works commission, a handsome row of barracks, a military hospital, and a French hospital. All these are sightly structures; but they make little show amid their squalid surroundings.

Adrianople has five faubourgs, of which Kiretchhané and Yildirim are on the left bank of the Maritza, and Kirdjik stands on a hill overlooking the city. The two last-named are exclusively Greek, but a large proportion of the inhabitants of Kiretchhané is Bulgarian. These three suburbs—as well as the little hamlet of Demirtash, containing about 300 houses all occupied by Bulgars—are all built in the native fashion; but the fifth suburb, Karagatch, which is on the right bank of the Maritza, and occupies the region between the railway station and the city, is western in its design, consisting of detached residences in gardens, many of them handsome villas and all of them comely structures of modern European type. In all the communities schools have multiplied, but the new seminaries are of the old non-progressive type. The only exception is the Hamidiah school for boys—a government institution which takes both boarders and day-scholars. Like the Lyceum of Galata Serai in Constantinople, it has two sets of professors, Turkish and French, and a full course of education in each language, the pupils following both courses. The several communities have each their own charitable institutions, the Jews being specially well endowed in this respect. The Greeks have a literary syllogos, and there is a well-organized club to which members of all the native communities, as well as many foreigners belong. The economic condition of Adrianople—city and province—was much impaired by the war of 1877-78, and was just showing signs of recovery when the severance from it of Eastern Rumelia by a Customs cordon rendered the situation worse than ever. Theretofore Adrianople had been the commercial *entrepôt* for the whole of Thrace, as it had been also, prior to the war, for a large proportion of the region between the Balkans and the Danube, now Bulgaria. But the separation of Eastern Romelia isolated Adrianople, and transferred to Philippopolis at least two-thirds of its foreign trade which, as regards sea-borne merchandise, is carried on through the port of Burghas. Sericulture, which prior to the war contributed largely to the prosperity of the town, suffered severely for a time, but about 1890 it began to show signs of revival which gradually developed. In 1897 and 1898 the output of silk increased in a remarkable degree, and in 1899 the crop equalled those of the most prosperous period which the silk industry has ever known in Adrianople. Unfortunately, the failure of the grain crops of the province in 1900 and in the four previous years almost neutralized the effect of these good silk harvests on the general prosperity of the population. The production of cheese continues steadily to increase. During the last few years great pains have been bestowed upon the improvement and extension of the fortifications, with the object of rendering them impregnable. In the opinion of military experts this object has been attained.

(E. W.*)

Adriatic. See MEDITERRANEAN.

Adullam, a city in the "lowland" of Judah, now Aid el-Ma, 7 miles north-east of Beit-Jibrin. The cave was near the city, and not near the Dead Sea. As a political expression the "cave of Adullam" first occurs in a Reform speech by Mr Bright in 1866.

Adulteration.—So many difficulties had been met with in the operation of the Adulteration of Food Act 1872, referred to in the ninth edition of this work, together with the Act of 1860, that in 1874 a Select Parliamentary Committee was appointed, which, after hearing much evidence, reported that, while the Act had done much good, it had at the same time inflicted considerable injury and enforced heavy and undeserved penalties upon some respectable tradesmen. "This appears to have been mainly due to the want of a clear understanding as to what does and what does not constitute adulteration, and in some cases to the conflicting decisions and inexperience of the analysts. Your committee are of opinion that the Act itself is defective and needs amendment." The Act had been but very partially applied; in most districts it had not been put into operation at all, in many no analysts had been appointed, in others no inspectors whose duty it would have been to purchase samples and submit them to the analysts for analysis. At that time but very few chemists had a competent knowledge of the composition of articles of food and of drink. The work in previous years had been carried on by amateurs, microscopists, and sensation-mongers, and no systematic steps had been taken to collect trustworthy analyses and to work out efficient and practicable methods of analysis. Upon the report of the Select Committee of 1874 the Sale of Food and Drugs Act 1875 was based, all previous Acts being repealed. This Act avoided the term "adulteration" altogether, and endeavoured to give a general definition of "food," of "drug," and of offences which would bring dealers in food and drugs into collision with the Act. The appointment of analysts was made incumbent upon the City of London, the vestries, all county quarter-sessions, and town councils of boroughs having a separate police establishment, and inspectors were empowered to collect samples for analysis. For the protection of the vendor such samples as were purchased for analysis were to be offered to be divided into three parts, one to be submitted to the analyst, the second to be given to the vendor to be dealt with by him as he might deem fit, whilst the third was to be retained by the purchasing inspector, and, at the discretion of the magistrates hearing any summons, to be submitted, in case of dispute, to the Commissioners of Inland Revenue for analysis by the chemical laboratory at Somerset House. The public analyst had to give a certificate to the person submitting any sample for analysis, which certificate was to be taken as evidence of the facts therein stated, in order to render the proceedings as inexpensive as possible. If the defendant in any prosecution proved to the satisfaction of the court that he had purchased the article under a warranty of genuineness, and that he sold it in the same state as when he purchased it, he was to be discharged from the prosecution, but no provision was made that in that event the giver of the warranty should be proceeded against. For admixing injurious substances with food or drug a fine not exceeding £50 could be imposed, or, after a conviction for a first offence, imprisonment for a period not exceeding six months with hard labour. For any ordinary practice of sophistication the maximum fine was fixed at £20.

Act of 1875.

Its difficulties.

The general definition above referred to, contained in clause 6 of the Act, was couched in the following words:—"No person shall sell to the prejudice of the purchaser any article of food or any drug which is not of the nature, substance, and quality of the article demanded by such purchaser; provided that an offence shall not be deemed to be committed in the following cases:—(1) Where any matter or ingredient not injurious to health has been added to the food or drug because the same is required for the production or preparation thereof as an article of commerce, in a state fit for carriage or consumption, and not fraudulently to increase the bulk, weight, or measure of the food or drug, or conceal the inferior quality thereof; (2) where the food or drug is a proprietary medicine or is the subject of a patent in force; (3) where it is compounded in accordance with the demand of the purchaser; and (4) where the food or drug is unavoidably mixed with some extraneous matter in the process of collection or preparation." This clause soon gave rise to an immense amount of litigation, and already in 1879 it was found necessary to pass a short Amendment Act, making it clear that if a purchase was effected by an inspector with the intent to get the purchased sample analysed he was as much "prejudiced" if obtaining a sophisticated article as a private purchaser who purchased an article for his own use and consumption. In the practical carrying out of the Act the chief difficulty was soon found to consist in ascertaining whether any article was "of the nature, substance, and quality demanded by the purchaser." This, on superficial consideration, seems to be a very simple matter. Thus, if a vendor supplies a customer who demands "milk" with milk and water, or with milk from which a part of the cream has been removed by skimming, it may appear to be a very easy task to ascertain whether the purchaser's demand has been complied with or not. But the composition of milk as yielded by the cow varies widely under different conditions, with the race and breed of the animal, its food, state of health, the period of lactation, the time of year, climate, &c. Thus, while a good Jersey cow might yield milk with 8 per cent. of fat, a Dutch cow might have but 2¾ or 3 per cent. of fat in its milk, and a great portion of the fat from the former might be removed before it fell to the level of the latter. Were the analyst to insist upon a standard of fat equal to that present in the best milk, many, even the majority of, genuine samples would have to be condemned, while, if he adopted the lowest recorded limit found in genuine milk, cream might be removed from almost all milk of normal nature, to the great damage of farmers and of the public. Similarly, but not quite to the same degree, there is a variation in the amount of the other food-constituents of milk, the so-called "solids-not-fat" or non-fatty solids, from the quantity of which the analyst concludes whether water has been added to the milk. It is obviously impossible to differentiate between the water which is natural to pure milk, and which constitutes the greater part of it, and between water that may have been fraudulently added to the article; but by the addition of water the constituents upon which the food-value of milk is dependent become depressed, and the depression is naturally in proportion to the quantity of added water. It required the united efforts of public analysts, who in 1875 founded the Society of Public Analysts, to ascertain by many tens of thousands of analyses of samples of milk the natural variation of the composition of milk, and to fix reasonable and fair limits applicable to pure milk. The milk yielded by single cows varies widely, and it is almost impossible to state the extremes, but the milk supplied to the public by vendors is almost invariably the mixed product of a herd, and extremes are equalized by such mixing. A monumental record of the composition of mixed milk was made by Dr Paul Vieth, who in 1892 published results of no less than 120,540 analyses of genuine milk, showing that the average composition varied in such manner that the percentage of fat was highest in September, October, and November, and lowest in June and July, while the proportion of "solids-not-fat" was subject to comparatively little variation, and that the numbers adopted by public analysts previously, namely, 3 per cent. for fat and 8.5 per cent. for solids-not-fat, were fair and equitable. Further reference will be found on this subject under the sub-heading "Milk" below. Similar difficulties are met with in all other articles of food, and, in fact, with annually extending experience, wider and wider variations in composition have been found, continually adding to the difficulty of arriving at a fair conclusion upon the basis of analysis. It may be said that a purchaser who obtains milk of extreme poverty, however untampered with, is prejudiced, because he expects to obtain milk of at least average quality, but the Food Acts are intended to repress and punish fraud only. While, however, milk vendors at first strongly opposed the use of more or less arbitrary limits of composition insisted upon by the executive officers, they slowly recognized that both the interest of the public and their own required them, and of late the raising of the limits has been favourably looked upon by some of the largest milk-vendors. By law no limit or standard is recognized at the present time, but a committee appointed by the Board of Agriculture have carefully inquired into the matter, and have recently reported officially recommending limits for the composition of milk, setting at rest a question which, since 1875, has given rise to a vast amount of labour and to numberless disputes.

A curious condition of things arose out of the definition of "food" as given in the Sale of Food Act 1875. "The term 'food' shall include every article used for food or drink by man, other than drugs or water." It had been the practice of bakers to add alum to the flour from which bread was manufactured, in order to whiten the bread and to permit the use of damaged and discoloured flour. This practice had been strongly condemned as early as the middle of the century by Liebig, as rendering the bread indigestible and injurious to health. Very shortly after the passing of the Food Act this objectionable practice disappeared, and alumed bread now no longer occurs. A large trade, however, continued to be carried on in baking powders consisting of alum and sodium bicarbonate, mainly used in private households. It was naturally thought that, as baking powder is sold with the obvious intention that it may enter into food, the vendors could also be proceeded against and the noxious trade stamped out. A strongly contested case having come before the High Court (*James* v. *Jones*) from the Swansea County Bench, it was held that baking powder was not an article of food, and that it was not an offence within the Food Acts to sell alumed baking powder. Following this decision it was obvious that spices, like pepper, cayenne, &c., were also not articles of food, and a further amendment of the law became inevitable. Before referring to the passing of the amended Act, which came into force in 1899, consideration must, however, be given to another fragment of piecemeal legislation, the Margarine Act of 1887. As early as the sixth decade of the 19th century substitutes for butter had been tried and had found a small market, mainly on the Continent. During the siege of Paris their manufacture received a powerful impulse, and soon after 1870 imitation-butter began to be sold in increasing quantities under the name of "butterine." This consisted of the softer portion of beef and other fats, coloured in imitation of butter, and churned with milk, often also flavoured with butter. The chief seat of manufacture of the article was, as it still is, in Holland, the raw material coming mostly from the United States. Although imported as an article essentially different from butter, its appearance, consistency, and name invited its substitution for real butter at the hand of unscrupulous traders; and there is no doubt that immense quantities of "butterine" were sold to the public as butter, to the great damage of farming and legitimate trade interests. Again a parliamentary committee sat and took evidence, and it was resolved to give a new name to the article, that of "margarine" (first given by Chevreul to a substance isolated by him from fats in beautiful pearly crystals), and to compel

Margarine.

the labelling and branding of all boxes and vessels in which the article was conveyed and stored, as well as the marking of the papers in which the retail dealer sold it, with the word "margarine," even mixtures of the substitute with real butter coming under that obligation. It was probably hoped that by these means the trade in butter-substitutes might be checked or destroyed, but the contrary happened, the new name soon taking root, and the sale of the article increasing by leaps and bounds, in spite of the great rate of increase in the import of genuine butter. Thus the Margarine Act ran conjointly with the original Food Act of 1875 and the Amendment Act of 1879. The result was a further increase in modifying decisions of High Courts and increasing difficulty in interpreting the meaning of the Acts. Growing dissatisfaction was expressed by the vendors, wholesale and retail, and by the authorities who had to see the Acts enforced, and the outcome of much agitation was once more a parliamentary committee, appointed in 1894, and reappointed in 1896 and 1897, voluminous evidence being taken and considered, resulting finally in a fourth Act, the Sale of Food and Drugs Act 1899, again superimposed over the three prior pieces of legislation.

Year.	Number of Samples.		Percentage of Adulteration.	Average percentage in Quinquennial Periods.
	Examined.	Adulterated.		
1877	14,706	2,826	19·2	1877-1881 16·2
1878	16,191	2,782	17·2	
1879	17,049	2,535	14·8	
1880	17,673	2,772	15·7	
1881	17,823	2,618	14·7	
1882	19,439	2,931	15·1	1882-1886 13·9
1883	19,648	2,955	15·0	
1884	22,951	3,311	14·4	
1885	23,230	3,076	13·2	
1886	23,596	2,813	11·9	
1887	24,440	3,134	12·8	1887-1891 11·7
1888	26,314	2,836	10·8	
1889	26,956	3,096	11·5	
1890	27,465	3,069	11·2	
1891	29,028	3,540	12·2	
1892	32,447	4,009	12·4	1892-1896 10·6
1893	37,233	4,793	12·9	
1894	39,516	4,060	10·3	
1895	43,962	4,093	9·3	
1896	45,555	4,202	9·2	
1897	46,856	4,383	9·4	
1898	49,555	4,319	8·7	
1899	53,056	4,970	9·4	

Samples Analysed under Food Acts in 1899.

Description.	Number of Samples.		Percentage Adulterated in	
	Examined.	Adulterated.	1899.	1898.
Milk	21,964	2,314	10·5	9·9
Bread	597	3	0·5	0·8
Flour	720	9	1·3	2·0
Butter	10,478	1,018	9·7	10·6
Coffee	1,929	145	7·5	10·6
Sugar	575	34	5·9	2·9
Mustard	693	22	3·2	3·9
Confectionery and Jam	511	14	2·7	2·9
Pepper	1,638	21	1·3	0·8
Tea	565	2	0·4	3·1
Lard	1,462	5	0·3	0·1
Wine	87	1	1·1	2·4
Beer	239	2	0·8	0·4
Spirits	4,724	611	12·9	12·4
Drugs	2,475	440	17·8	11·9
Other articles	4,399	329	7·5	5·0
Total	53,056	4,970	9·4	8·7

As to the working of the highly complicated machinery thus created since 1st January 1900 it is yet too early to speak, but of the beneficial results of the Sale of Food and Drugs Act 1875, broadly speaking, there cannot be any doubt. The preceding table, taken from the Report of the Local Government Board for 1900, shows clearly that the percentage of adulterated articles has steadily declined since 1877 from 19 per cent. of all samples analysed to 9 per cent.

Working of the Acts.

The effect, gratifying as it is, would have been still greater if many towns and districts had not neglected, in spite of pressure brought to bear upon them by Government and others, to put the Acts into operation. The Acts compel the authorities to appoint analysts, but until the Act of 1899 no means existed to force unwilling councils to collect samples for analysis, or in many cases only so small and insignificant a number that food control was virtually non-existent. As far, however, as statistics are available, figures prove that in districts where the Acts are more or less feebly administered the proportion of adulteration is greater than in others that vigorously apply the legal means for repressing fraud. Thus in 1890, Somersetshire, working the Acts efficiently, took one sample for analysis per annum for every 379 inhabitants, and the percentage of adulterated articles found was only 3·6, or only about one third of the amount representing the average for the whole country. Gloucestershire, with one sample for 770 inhabitants, had 6·2 per cent. of adulteration; Hampshire, with one sample for 1224 inhabitants, 12·2 per cent.; Derbyshire, with one sample for 3164 inhabitants, 17·1 per cent.; Oxfordshire, with only one sample for 14,963, no less than 41·7 per cent. of adulterated articles. Even in 1899 no samples whatever were officially analysed in seven English boroughs, while within the jurisdiction of six counties and seven boroughs, with a total population of 600,000, only 139 samples were analysed during the year, and in 65 other districts the proportion examined was less than was deemed sufficient by the Local Government Board. The public authorities, at the same time, recognize in most cases the material public benefit conferred by the various enactments. In 1899, 53,056 samples were examined by public analysts: 4970 were reported against, and proceedings were instituted against 3110 vendors—fines amounting to £6258 being imposed.

Scientific adulteration.

The increased vigilance on the part of the public officers is met by an increased application of science to adulteration. Thus, for some years the substitution of margarine for butter, an unabashed fraud, was common. The substitution, owing to advance in methods of chemical analysis, being readily discoverable since 1874 and punished, mixtures of butter with gradually decreasing percentages of margarine were made and sold; and at the present time large quantities of mixtures, containing not more than 8 to 10 per cent. of margarine, are freely imported from abroad and sold as "warranted pure" butter, the mixing being done with the assistance of skilled chemists, who, knowing the composition of the pure article, carefully let it down by the addition of margarine to such a point that the mixture still possesses the characters of pure, though slightly abnormal butter, against which proceedings could not be undertaken with probability of conviction of the vendor. Margarine, specially adapted for this fraud, is made by Dutch manufacturers. In milk, similarly, the skilful vendor, knowing the natural variations of milk, dilutes or skims it to the exact point which experience has shown to render him reasonably safe from detection. The whole of the information contained in analytical literature, primarily for the benefit of the analyst, is available to the fraudulent manufacturer, and no new process of analysis appears without immediate effort on the part of the mixer to circumvent and defeat it. Two practices which are closely akin to adulteration, if not actually such, have much engaged the attention of analysts during the last few years—namely, the addition of chemical preservatives and of colouring matters to articles of food. Chemical preservatives are contained in many perishable articles—namely, sulphite of lime in beer, syrups, meat, lime-juice, &c.; salicylic acid sometimes in wines and often in jams; formaldehyde (formaline) in milk. But by far the most frequently used materials are borax and boracic acid, almost universally present in imported butter (with the exception of Danish butter), and in much that is made in Great Britain, in cured ham, in fish, cream, and milk. A preservative acts as a bactericide, and in no case is physiologically inert, although the dose taken at a meal may not be sufficient to produce obvious effects. Medical opinion is, however, at present almost unanimous that the continual use of preservatives cannot fail to be injurious to the human system, and the increasing infant mortality in some towns is attributed to the fact that the milk used by the infants is now so frequently borated. A Committee appointed by the Board of Agriculture has been engaged on this subject, but at the time of writing no report has yet been made public. The employment of preservatives is justified by dealers in perishable articles by pointing to the difficulty which would otherwise be experienced in collecting in distant countries food-materials like butter, shipping them to England, and distributing them to the public without loss of quality; on the other hand, modern means of preserving food, in cold-store, &c., are being pointed to as fully sufficient to meet all wants without the introduction of foreign matters.

Colouring matters, quite harmless in themselves, are largely used at the present time in many articles of food and drink. Originally the use of a yellow dye in milk was due to a fraudulent motive, namely, to hide the blueness produced by watering. Gradually the public, especially in London, became accustomed to see their milk of a distinct yellow tint, and all milk, even genuine milk free from added water, sold in London, is now coloured, generally with anatto, often with aniline dye; and it would be almost impossible for a vendor to sell milk of its natural colour. Again, all butter sold in London and the South of England is coloured yellow. Natural butter has often a very faint fawn tint, and the public, educated to see butter yellow, would not purchase such butter; hence the now universal colouring adopted. The Food Act cannot cope with this practice, as long as the object of colouring is not a fraudulent one and the colour itself is harmless. The colouring of preserved peas by the use of a little copper sulphate is on a different basis, as the copper is considered liable to produce injury to health, and many vendors of coppered peas have been fined during recent years; yet the public object to purchase preserved peas of the natural brown colour. Jams are very frequently dyed, and the brilliantly coloured jams now sold owe most of their colour to coal-tar dyes, which are often employed to hide the fact that unripe or inferior fruit has been used by the manufacturer.

We will now consider recent forms of adulteration in specific articles, and the means adopted for their detection.

Milk.—Although the general qualitative composition of milk has been known for very many years, all quantitative statements concerning the proportion of the several constituents published before 1884 are affected with considerable errors. About 1872 Wanklyn showed that, although, as was well known, the percentage of the fat of milk was subject to very considerable fluctuation, when the percentage of milk-sugar, caseine, and other albuminoids and mineral water was added together, the "solids-not-fat" varied but little, and he proposed to utilize that fact to determine whether milk was genuine or had been impoverished by the addition of water,—it being evident that water would diminish the percentage of solids-not-fat, the percentage of addition being readily calculated from the amount of the latter. Although the method of ascertaining the proportion of "solids-not-fat" adopted by Wanklyn has been shown to be somewhat erroneous, the principle of analysis established by him has remained the basis upon which milk-analysis rests, and public analysts virtually adopted the limits proposed by him—viz., 2·5 per cent. of fat and 9 per cent. of solids-not-fat. In 1884 M. A. Adams showed, however, that the then usual method of analysis did not allow of the complete removal of the fat from the other milk-constituents, that therefore the proportion of fat had been underestimated, the amount of the solids-not-fat being correspondingly too high. By the simple and ingenious expedient of spreading a known volume of the milk to be analysed upon a long strip of blotting-paper and extracting the paper together with the dried milk by a solvent, such as ether or benzene, the fat could be completely removed from all other constituents. After full investigation the Society of Public Analysts altered the limits, in accordance with the new discovery, to 3 per cent. as a minimum for the fat and 8·5 per cent. for the solids-not-fat. As the average composition of genuine milk, according to Vieth, is 4·1 per cent. of fat, 8·8 of solids-not-fat, and 12·9 per cent. of total matter other than water, it is obvious that the limits allow for a reasonable departure from the average. The Board of Agriculture's Departmental Committee has quite recently issued a report, in which the following recommendations are made as to proportions of food constituents which should be present in milk. The percentage of total solids must not be less than 12, the proportion of solids-not-fat not less than 8·5 per cent., and that of fat at least 3·25. If the amounts are smaller, a presumption is raised, unless the contrary is proved, that the milk is adulterated by skimming or watering. The recommendations of the Committee are most valuable, as tending to the improvement in the breed of dairy cattle, and cows yielding milk poorer than the above will probably be weeded out and replaced by superior breeds. A number of means are now known allowing of the complete analytical separation of the fat other than the "Adams" method. The "galactometer" and "lactometer" instruments, referred to in the article in the ninth edition of this work, have long been abandoned. Other far more exact and more rapid means have been found to determine the composition of milk with a degree of accuracy sufficient for practical, especially dairying, purposes. As the fat of milk is its most valuable and most important constituent, it is of high importance to the butter-producer in particular to know the exact proportion of the fat, partly in order to know that he obtains value for his money, and also to check the efficiency of the working of his appliances for separating the cream—centrifugals being now universally employed for that purpose. By centrifugal force alone the fat globules of milk do not coalesce into a layer of pure fat; if, however, an acid, like hydrochloric or sulphuric acid, be added to the milk in sufficient quantity prior to subjecting it to centrifugal force a clear layer of pure butter-fat separates, and if a measured quantity of milk be taken and the volume of the separated fat be determined, generally in a graduated glass-tube, the amount of fat in any sample of milk can be arrived at in a few minutes. Upon this principle a number of instruments have been designed and render excellent service in the creamery and laboratory. As, moreover, a definite relation exists between the specific gravity of a milk and its contents in fat and solids-not-fat, it follows that the specific gravity of a milk being known and its contents in fat, the proportion of solids-not-fat can be calculated. Formulæ for that end have been worked out by a number of chemists. An analysis of milk, showing the specific gravity, the percentage of fat and that of solids-not-fat can therefore now be made in as many minutes as the hours formerly required, and in scientifically conducted dairies the price paid for the milk is regulated by the analytical data obtained.

No forms of adulteration occur except the addition of water, the removal of cream (or its equivalent, the addition of skim-milk), and, if adulteration it be, the addition of preservatives. All statements as to the occurrence of chalk and of sheep's brains are fables. Although the addition of water is still a common form of adulteration, the percentage of added water is mostly not greater than from 8 to 15, and the grosser and more impudent frauds commonly met with twenty years ago have practically been stamped out. A number of the large dairies supplying London and other large towns have fully equipped laboratories, with a staff of highly trained chemists, analysing almost each churn of milk delivered by the farmers, adulteration being thus as completely prevented as possible. Against the skimming of milk the means available are not so effective as those against watering, as the natural variation of the amount of fat is so considerable, partially skimmed Jersey milk still containing as much fat as unaltered milk from lowland cattle.

Butter.—Since the introduction of margarine, frauds in the butter trade are exclusively confined to two kinds—namely, the substitution of margarine for and the addition of margarine to butter, and the incorporation or undue retention of water. Referring firstly to the latter form of adulteration, it must be borne in mind that all butter contains water. Properly-made butter contains, as a rule, 11 to 15 per cent.; it is not practicable to remove a larger proportion by rolling or squeezing, as the consistency of the butter suffers; 16 or at most 17 per cent. of water may legitimately be present in good butter. If, however, the churning of the cream is carried out at too high a temperature, an emulsion of water and butter is formed, containing as much as 30 or even 40 per cent. of water, causing the article to assume an ointment-like appearance. In properly-equipped dairies, refrigeration of the cream, if needful, is adopted to reduce the temperature of the cream in summer; but in small and old-fashioned dairies, as in many of those in the West of Ireland, these means are not available, and Irish butter, therefore, often contains an excess of water, 25 per cent. and over. As in most cases magistrates have declined to consider this as an adulteration, and often enough the petty farmers are not to be blamed, the wilful introduction of water into butter has at times been carried out on an industrial scale, and even at the present time much butter is sold which has been loaded with water up to 28 and more per cent., with of course good profit to the "manufacturer."

Chemical differentiation between butter and butter-substitutes, now called margarine, was unknown prior to 1873, when the writer, with A. Angell, published a method which readily allowed of such differentiation, and of the estimation of the proportions of butter-fat and other fat contained in a mixture, based upon the fact that while fats other than butter-fat (and cocoa-nut oil) contain about 95·5 per cent. of fatty acids insoluble in water, butter-fat contains a smaller quantity—namely, about 86 to 88 per cent.—the difference being due to the presence of a corresponding amount of water-soluble fatty acids. Various modifications and simplifications of this principle have since been worked out, and the detection of margarine in butter, if present in substantial amount, has been rendered easy and certain. In the case of butter, as in that of milk, the analyst has, however, to reckon with natural variations in the composition of the butter-fat itself, and no means have yet been discovered whereby percentages smaller than 10 per cent. can be discovered with sufficient certainty to lead to the conviction of the vendors. It is a singular fact that while, as a rule, the composition of the butter-fat is almost independent of the food of the animal, under some conditions depending mainly upon the period of lactation, the composition of the fat undergoes material changes, so that a cow in the last stages of lactation may yield milk, small in quantity, from which butter can be churned which analyses as if it were a mixture of butter and margarine. Luckily it happens but rarely in practice that all the cows of a whole herd become "dry" at the same time; hence the natural variation in composition equalizes itself as a rule. There are, however, a few cases on record, notably one carefully worked out by A. H. Allen, in which butter was made under strict supervision in Denmark from absolutely pure materials, yet analysed like a mixture. It is doubtful therefore whether adulteration of butter with small amounts of margarine can ever be quite prevented by certain discovery, especially if the admixture is made, as in some parts of Holland, with the active aid of skilled chemists. When it is considered that England imports about ten million pounds sterling worth of butter per annum, the immense importance of preventing substitution of margarine, of approximately half the price of butter, will be apparent.

Some most ingenious instruments have been constructed, notably Abbe's refractometer, with a view to obtain by physical means data for discrimination between butter and mixtures. Melted butter-fat refracts light to a less degree than do butter-substitutes; the instrument in question allows of the determination of the "index of refraction" by the use of a mere droplet of the butter-fat, and is a most valuable tool in the hands of the chemist.

Cheese.—From America cheese has come into the English market, made from skim-milk which has again been provided with fatty matter, generally emulsified margarine—hence the term "margarine cheese," or "filled cheese"—a legitimate article if sold with full disclosure of its nature, but one which readily lends itself to fraud. Cases of cheese-poisoning have been recorded, and a highly poisonous substance, termed tyrotoxicon, has been extracted from cheese by Vaughan. Compounds of zinc and of lead have also been met with.

Lard.—Between the years 1880 and 1890 a gigantic, fraudulent trade in adulterated lard was carried on from America. A great proportion of the American lard imported into England was found to consist of a mixture of more or less real lard, with cotton-seed oil and beef-stearine. Cotton-seed oil is one of the cheapest vegetable oils fit for human consumption; beef-stearine, the hard residue obtained in the manufacture of oleomargarine after the more fluid fat has been pressed out from the beef-fat. So skilfully were the mixtures made that for some years their very existence escaped notice, until in 1888 a bill introduced in the American Senate to stop the imposture directed general attention to the matter, and energetic measures by the food-officers quickly put a stop to it as affecting the United Kingdom. From the memorial presented to the U.S. Senate in support of the bill, it appeared that in about 1887 the annual production of lard in the States was estimated at 600 million pounds, of which more than 35 per cent. were adulterated. During the last seven or eight years compounds have been made containing no lard or only a faint trace of lard. These compounds were sold as "refined lard," "pure refined lard," "choice refined lard," "choice refined family lard," and other similar names. Professor Wiley, in his evidence on the subject, said that "Messrs Armour and Co. state that they use from 59 to 75 per cent. of lard in their mixtures, Fairbank from 50 to 75 per cent. The former firm use 75,000 barrels of cotton-seed oil, and make 60 million pounds refined lard. 75,000 barrels weigh 28 million pounds: hence the average proportion would be 46 per cent. of cotton-seed oil in the mixture; but as from 10 to 15 per cent. of beef-stearine are necessary to stiffen the mixture, the proportion of lard would be only about 42 per cent."

Oils.—Since the article in the ninth edition of this work appeared, enormous progress has been made in the chemical knowledge of fats and oils, and complicated mixtures of various oils can now be satisfactorily analysed. Perhaps the most important step was taken by Allen and von Huebl, who showed that different fats and oils were capable of combining with different percentages of bromine or iodine, the "iodine-absorption" number being characteristic for each class of oils—the olive-oil group showing about 80-90 per cent.; the cotton-oil group about 105-110; linseed-oil, 160-170. This number, together with a determination of the saponification-value (the amount of caustic alkali needed for complete saponification), the thermal rise with strong sulphuric acid (Maumene), or bromine (Hehner and Mitchell), the refraction of light and the specific gravity, enable the analyst to form in most cases a close idea as to the nature of any sample under examination. The adulteration of oils has in consequence become far less. Cotton-seed oil and, latterly, the oil expressed from the maize-germ (maize oil), are the most common fatty adulterants, but much use is also made in this direction of paraffin oils and resin oil. So-called olive oil frequently consists of a mixture of olive oil, cotton-seed oil, earthnut (arachis) oil, and sesame-seed oil, one or the other of these being sometimes altogether substituted for genuine olive oil. Odourless paraffin hydrocarbons also enter into these adulterated articles.

Pepper.—Some years ago ground olive-kernels were largely sold for admixture with pepper, under the name of "poivrette." They were easily recognizable on microscopic examination and the fraud did not live long. The older forms of adulteration (rice and other farinaceous meals) also still occur.

Ginger.—The more or less exhausted ginger resulting in the manufacture of ginger beer used until lately to be re-dried, ground, and mixed with fresh ginger—a great proportion of commercial ground ginger consisting of so-called "spent" ginger. If exhausted by water the proportion of the water-soluble constituents of ginger—if by alcohol, those of the alcohol-soluble ones—were reduced by the treatment, thus affording to the analyst guidance in coming to a judgment. Similar fraud exists in the case of aromatic substances from which valuable oils can be extracted, the exhausted ground stuff being sold in admixture with the genuine.

Beer.—In 1899 an obscure illness broke out in Dublin resembling the tropical disease "beri-beri." Early in August 1900 a rapid increase in the number of "peripheral neuritis" cases, closely resembling the Dublin beri-beri cases, was observed in Lancashire. It soon became clear that there was some connexion between the drinking of beer and the obscure disease; and Dr. Reynolds, Physician to the Royal Manchester Infirmary, on investigation found arsenic in the suspected beer. This discovery caused an immense amount of attention to be given to beer. Traces of arsenic were found in samples from many parts of the country; but the greatest amounts of arsenic (up to 1 grain per gallon, calculated as arsenious acid, has been met with) were traced to the employment in a number of breweries of some starch-glucose that had been manufactured by the aid of very impure, arsenical, sulphuric acid by a Lancashire firm. Numerous deaths were due to the drinking of such arsenicated beer. It was also soon discovered that much of the malt used by brewers contained appreciable traces of arsenic, and in hops small traces were found. Malt and hops probably derive their arsenic from the fact that both are prepared by an antiquated process, the drying of both being effected by the gases and fumes which are given off by coke or anthracite fires, these fumes passing through the malt and hop, which absorb therefrom any arsenic that may be associated with the pyrites occurring in all coal. Sulphur, often arsenical, is also sprinkled upon the fires to lighten the colour of malt or hop. All the worst cases, however, of arsenic in beer were due to arsenical glucose, prepared by one firm. The use of glucose is perfectly legal, the brewer having the statutory right to brew from whatever material he may deem proper, as long as he pays due revenue to the State—the revenue being levied upon the basis of the specific gravity of the wort, every liquor under the Customs and Inland Revenue Act, 1885, being defined as beer, "which is made or sold as a description of beer, or as a substitute for beer, which on analysis of a sample thereof shall be found to contain more than 2 per cent. of proof spirit." The fact that arsenic was liable to occur in glucose and in beer was known as long ago as 1878, but no quantities in any way resembling those met with in the recent cases had previously been observed. Since the use of glucose has become general in brewing, other industrial users of sugar, principally the manufacturers of sweetmeats, jams, and syrups, have also largely employed glucose, mainly for the cheapening of their products. No doubt the strict supervision which will henceforth be exercised over the purity of glucose will render an occurrence such as that of beer-poisoning by arsenic unlikely in the future; but a strong desire has been aroused to draw a distinction by Act of Parliament between beer made from malt and hops and such as may be prepared from substitutes.

(O. H.*)

Advertisement, or advertising, as the process of purchasing publicity is now more commonly called, is of very recent origin if it be regarded as a serious adjunct to other phases of commercial activity. In some rudimentary form the seller's appeal to the buyer must, however, have accompanied the earliest development of trade. Under conditions of primitive barter, communities were so small that every producer was in immediate personal contact with every consumer. As the primeval man's wolfish antipathy to the stranger of another pack gradually diminished, and as intercourse spread the infection of larger desires, the trapper could no longer satisfy his more complicated wants by the mere exchange of his pelts for his lowland neighbour's corn and oil. A began to accept from B the commodity which he could in turn deliver to C, while C in exchange for B's product gave to A what D had produced and bartered to C. The mere statement of such a transaction sufficiently presents its clumsiness, and the use of primitive forms of coin soon simplified the original process of bare barter. It is reasonable to suppose that as soon as the introduction of currency marked the abandonment of direct relations between purchaser and consumer an informal system of advertisement in turn rose to meet the need of publicity. At first the offer of the producer must have been brought to the trader's attention, and the trader's offer to the notice of the consumer, by casual personal contact, supplemented by local rumour. The gradual growth of markets and their development into periodical fairs, to which merchants from distant places resorted, afforded, until printing was invented, the only means of extended advertisement. In England, during the 3rd century, Stourbridge Fair attracted traders from abroad as well as from all parts of England, and it may be conjectured that the crying of wares before the booths on the banks of the Stour was the first form of advertisement which had any marked effect upon English commerce. As the fairs of the Middle Ages, with the tedious and hazardous journeys they involved, gradually gave place to a more convenient system of trade, the 15th century brought the invention of printing, and led the way to the modern development of advertising. The Americans, to whom the elaboration of newspaper advertising is primarily due, had but just founded the first English-speaking community in the Western hemisphere when the first newspaper was published in England. But although the first periodical publication containing news appeared in the month of May 1622, the first newspaper advertisement does not seem to have been published until April 1647. It formed a part of No. 13 of *Perfect Occurrences of Every Daie journall in Parliament, and other Moderate Intelligence*, and it read as follows :—

> A Book applauded by the Clergy of *England*, called *The Divine Right of Church Government*, Collected by sundry eminent Ministers in the Citie of *London*; Corrected and augmented in many places, with a briefe Reply to certain *Queries* against the Ministery of *England*; Is printed and published for *Joseph Hunscot* and *George Calvert*, and are to be sold at the Stationers' Hall, and at the Golden Fleece in the Old Change.

Among the *Mercuries*, as the weekly newspapers of the day were called, was the *Mercurius Elencticus*, and in its 45th number, published on 4th October 1648, there appeared the following advertisement :—

> The Reader is desired to peruse a Sermon,
> Entituled *A Looking-Glasse for Levellers*,
> Preached at St. Peters, Paules Wharf, on Sunday, Sept. 24th 1648,
> by Paul Knell, Mr. of Arts. Another Tract called *A Reflex*
> *upon our Reformers, with a prayer for the Parliament.*

In an issue of the *Mercurius Politicus*, published by Marchmont Nedham, who is described in the ninth edition of the *Encyclopædia Britannica* (see NEWSPAPERS, vol. xvii. p. 414) as "perhaps both the ablest and the readiest man that had yet tried his hand at a newspaper," there appeared in January 1652 an advertisement, which has often been erroneously cited as the first among newspaper advertisements. It read as follows :—

> Irenodia Gratulatoria, a heroic poem, being a congratulatory panegyrick for my Lord General's return, summing up his successes in an exquisite manner. To be sold by John Holden, in the New Exchange, London, Printed by Thomas Newcourt, 1652.

The article "On the Advertising System," published in the *Edinburgh Review* for February 1843, contains the fullest account of early English advertising that has ever been given, and it has been very freely drawn upon by all writers who have since discussed the subject. But it describes this advertisement in the *Mercurius Politicus* as "the very first," and the discovery of the two earlier instances above quoted was due to the researches of a contributor to *Notes and Queries*.

In *The Crosby Records*, the commonplace-books of William Blundell, there is an interesting comment, dated 1659, on the lack of advertising facilities at that period—

> It would be very expedient if each parish or village might have some place, as the church or smithy, wherein to publish (by papers posted up) the wants either of the buyer or the seller, as such a field to be let, such a servant, or such a service, to be had, &c. There was a book published in London weekly about the year 1657 which was called (as I remember) *The Publick Advice*. It gave information in very many of these particulars.

A year later the same diarist says—

> There is an office near the Old Exchange in London called the office of Publick Advice. From thence both printed and private Information of this useful nature are always to be had. But what they print is no more than a leaf or less in a diurnal. I was in this office. The diurnal consisted of sixteen pages quarto in 1659.

In No. 62 of the *London Gazette*, published in June 1666, the first advertisement supplement was announced—

> An Advertisement—Being daily prest to the Publication of Books, Medicines, and other things not properly the business of a Paper of Intelligence, This is to notifie, once for all, that we will not charge the *Gazette* with Advertisements, unless they be matter of State: but that a Paper of Advertisements will be forthwith printed apart, & recommended to the Publick by another hand.

In No. 94 of the same journal, published in October 1666, there appeared a suggestion that sufferers from the Great Fire should avail themselves of this means of publicity—

> Such as have settled in new habitations since the late Fire, and desire for the convenience of their correspondence to publish the place of their present abode, or to give notice of Goods lost or found, may repair to the corner House in Bloomsbury on the East Side of the Great Square, before the House of the Right Honourable the Lord Treasurer, where there is care taken for the Receipt and Publication of such Advertisements.

The earlier advertisements, with the exception of formal notices, seem to have been concerned exclusively with either books or quack remedies. The first trade advertisement, which does not fall within either of these categories, was curiously enough the first advertisement of a new commodity, tea. The ninth edition of the *Encyclopædia Britannica* (see TEA, vol. xxiii. p. 101) quotes this advertisement from the *Mercurius Politicus*, No. 435, for September 1658—

> That excellent and by all Physitians approved China Drink, called by the Chineans *Tcha*, by other nations *Tay*, alias *Tee*, is sold at the Sultaness Head, a cophee-house in Sweetings Rents, by the Royal Exchange, London.

The history of slavery, of privateering, and of many other curious incidents and episodes of English history during the 17th and 18th centuries, might be traced by examination of the antiquated advertisements which writers upon such subjects have already collected. In order that space may be found for some consideration of the practical aspects of modern advertising, the discussion of its gradual development must be curtailed. Nor is it necessary to preface this consideration by any laboured statement of the importance which advertising has assumed.

It is a matter of common knowledge that several business houses are to be found in Great Britain, and a larger number in the United States, who spend not less than £50,000 a year in advertising, while one patent medicine company, operating both in England and the United States, has probably spent not less than £200,000 in Great Britain in one year, and an English cocoa manufacturer is supposed to have spent £150,000 in Great Britain. Some of the best works of artists as distinguished as Sir John Millais, Professor Herkomer, and Mr. Stacy Marks, have been scattered broadcast by advertisers. The purchase of Sir John Millais' picture "Bubbles" for £2200 by the proprietors of a well-known brand of soap, is probably the most remarkable instance of the expenditure in this direction which an advertiser may find profitable. There are in London alone more than 350 advertising agents, of whom upwards of a hundred are known as men in a considerable way of business. The statements which from time to time find currency in the newspapers with regard to the total amount of money annually spent upon advertising in Great Britain and in the United States are necessarily no better than conjectures, but no detailed statistics are required in order to demonstrate what every reader can plainly see for himself, that advertising has definitely assumed its position as a serious field of commercial enterprise.

Advertising, as practised at the beginning of the 20th century, may be divided into three general classes :—

1. Advertising in periodical publications.
2. Advertising by posters, sign-boards (other than those placed upon premises where the advertised business is conducted), transparencies, and similar devices.
3. Circulars, sent in quantities to specific classes of persons to whom the advertiser specially desired to address himself.

It may be noted at the outset that advertising in periodical publications exercises a reflex influence upon these publications. The daily, weekly, and monthly publications of the day are accustomed to look to advertisements for so large a part of their revenue that the purchaser of a periodical publication receives much greater value for his money than he could reasonably expect from the publisher if the aggregate advertising receipts did not constitute a perpetual subsidy to the publisher. It is not to be supposed, however, that the receipts from the sale of a paper cover all its expenses and that the advertising revenue is all clear profit. The average newspaper reader would be amazed if he knew at how great a cost the day's news is laid before him. A dignified journal displays no inclination to cry from the housetops the vastness of its expenditure, but from time to time an accident enables the public to obtain information in this connexion. The evidence taken by a recent Copyright Commission disclosed that the expenditure of the leading English journal upon foreign news alone amounted to more than £50,000 in the course of one year, and that a year not characterized by any great war to swell the ordinary volume of cable despatches.

In the case of daily papers sold at the minimum price, it is not less obvious that the costliness of news service renders advertising revenue indispensable, for although these less important journals spend less money, the price at which they are supplied to the newsagents is very small in proportion to the cost of their production. If, however, this thought be pursued to its logical conclusion, the advertiser must admit that he in turn receives, from those among newspaper readers who purchase his wares, prices sufficiently high to cover the cost of his advertising. So that the reader is in the curious position of directly paying a certain price for his newspaper, receiving a newspaper fairly worth more than that price, while this price is supplemented by the indirect incidence of a sort of tax upon many of the commodities he consumes. On the other hand, a great part of the advertisements in a daily newspaper have themselves an interest and utility not less than that possessed by the news. The man who desires to hire a house turns to the classified lists which the newspaper publishes day after day, and servants and employers find one another by the same means. The theatrical announcements are so much a part of the news that even if a journal were not paid for their insertion they could not be altogether omitted without inconvenience to the reader. In the main, however, it is the advertiser who seeks the reader, not the reader who seeks the advertiser, and the care with which advertisements are prepared, and the certainty with which the success or failure of a trader may be traced to his skill or want of skill as an advertiser, show that the proper use of advertising is one of the most indispensable branches of commercial training.

Poster and sign advertisements.

Before discussing in detail the methods of advertising in periodical publications it may be well to complete, for the use of the general reader, a brief survey of the whole subject by examining the two other classes of advertisement. The most enthusiastic partisan of advertising will admit that posters and similar devices are very generally regarded by the public as sources of annoyance. A bold headline or a conspicuous illustration in a newspaper advertisement may for a moment force itself upon the reader's attention. In the French, and in some English newspapers, where an advertisement is often given the form of an item of news, the reader is distressed by the constant fear of being hoodwinked. He begins to read an account of a street accident, and finds at the end of the paragraph a puff of a panacea for bruises. The best English and American journals have refused to lend themselves to this sort of trickery, and in no one of the best journals printed in the English language will there be found an advertisement which is not so plainly differentiated from news matter that the reader may avoid it if he sees fit to do so. On the whole, then, newspaper advertisements ask, but do not compel attention. The whole theory of poster advertising is, on the other hand, one of tyranny. The advertiser who pays for space upon a hoarding or wall, although he may encourage a form of art, deliberately violates the wayfarer's mind. A trade-mark or a catch-word presents itself when eye and thought are occupied with other subjects. Those who object to this class of advertisement assert, with some show of reason, that an advertisement has no more right to assault the eye in this fashion than to storm the ear by an inordinate din ; and a man who came up behind another man in the street, placed his mouth close to the other's ear, and bawled a recommendation of some brand of soap or tobacco, would be regarded as an intolerable disturber of public peace and comfort. Yet if the owner of a house sees fit to paint advertisements upon his walls, his exercise of the jealously guarded rights of private property may not lightly be disturbed. For the most part, both law and public opinion content themselves with restraining the worst excesses of the advertiser, leaving many sensitive persons to suffer. The National Society for Checking the Abuses of Public Advertising, founded in 1893 in London, was organized for purposes which it describes as follows :—

> The society aims at protecting the picturesque simplicity of rural and river scenery, and promoting a regard for dignity and propriety of aspect in towns—with especial reference to the abuses of spectacular advertising.
>
> It seeks to procure legislation whereby local representative bodies would be enabled to exercise control, by means of bye-laws framed with a view to enabling them, at any rate, to grant relief in cases of flagrant and acknowledged abuse.
>
> It is believed that, when regulation is applied in cases where local conditions are peculiarly favourable, the advantage will be so apparent that, by force of imitation and competition, the enforcement of a reasonable standard will gradually become common. The degree of restraint will, of course, depend upon the varying requirements of different places and positions. No hard and fast rule is suggested ; no particular class of advertisement is proscribed ; certainly no general prohibition of posters on temporary hoardings is contemplated. Within the metropolitan area sky signs have already been prohibited, and it is hoped that some corresponding check will be placed on the multiplication of the field boards which so materially diminish the pleasure or comfort of railway journeys.
>
> The society regards with favour the imposition of a moderate tax or duty for imperial or local purposes on exposed advertisements not coming within certain categories of obviously necessary notices. The difficulty of inducing a Chancellor of the Exchequer to move in a matter where revenue is not the primary consideration is not overlooked. But it is thought that any impost would materially reduce the volume of exposed advertisements, and would at once extinguish the most offensive and the most annoying class, *i.e.*, the quack advertisements by the road sides and the bills stuck by unauthorized persons on trees, walls, and palings.
>
> Members are recommended to make it known that there exists an active repugnance to the present practice of advertising

disfigurement, by giving preference, in private transactions, to makers and dealers who do not employ objectionable methods, and by avoiding, as far as possible, the purchase of wares which, in their individual opinion, are offensively puffed. Action on these lines is advised rather for its educational than for its immediately deterrent effect; although, in the case of many of the more expensive commodities, makers would undoubtedly be much influenced by the knowledge that they would lose, rather than gain, custom.

The foregoing proposals are based on the following estimate of the conditions of the problem. It is believed that the present licence causes discomfort or loss of enjoyment to many, and that, in the absence of authoritative restriction, it must grow far beyond its present limits; that beauty or propriety of aspect in town and country form as real a part of the national wealth as any material product, and that to save these from impairment is a national interest; that the recent developments of vexatiously obtrusive advertising have not grown out of any necessities of honourable business, but are partly the result of a mere instinct of imitation, and partly are a morbid phase of competition by which both the consumers and the trade as a whole lose; that restriction as regards the size and positions of advertising notices would not be a hardship to those who want publicity—since all competitors would be treated alike, each would have the same relative prominence; that, as large sums of public money are expended on institutions intended to develop the finer taste, and on edifices of elaborate design, it must be held inconsistent with established public policy to permit the sensibilities thus imparted to be wounded, and architectural effect to be destroyed at the discretion of a limited class.

The influence of this society is to be seen in many of the restrictions which have been imposed upon advertisers since its work began. About a year after its foundation the London County Council abolished (under statutory powers obtained from Parliament) advertisements coming within the definition of sky-signs in the London Building Act of 1894. These specifications are as follows:—

"Sky sign" means any word, letter, model, sign, device, or representation in the nature of an advertisement, announcement, or direction supported on or attached to any post, pole, standard, framework, or other support, wholly or in part upon, over, or above any building or structure, which, or any part of which, sky sign shall be visible against the sky from any point in any street or public way, and includes all and every part of any such post, pole, standard, framework, or other support. The expression "sky sign" shall also include any balloon, parachute, or similar device employed wholly or in part for the purposes of any advertisements or announcement on, over, or above any building, structure, or erection of any kind, or on or over any street or public way.

The Act proceeds to exclude from its restrictions flagstaffs, weathercocks, and any solid signs not rising more than 3 feet above the roof.

Another bye-law of the London County Council, in great measure due to the observations made at coroners' inquests, protects the public against the annoyances and the perils to traffic occasioned by flashlight and searchlight advertisements. This bye-law reads as follows:—

No person shall exhibit any flashlight so as to be visible from any street and to cause danger to the traffic therein, nor shall any owner or occupier of premises permit or suffer any flashlight to be so exhibited on such premises.

The expression "flashlight" means and includes any light used for the purpose of illuminating, lighting, or exhibiting any word, letter, model, sign, device, or representation in the nature of an advertisement, announcement, or direction which alters suddenly either in intensity, colour, or direction.

No person shall exhibit any searchlight so as to be visible from any street and to cause danger to the traffic therein, nor shall any owner or occupier of premises permit or suffer any searchlight to be so exhibited on such premises.

The expression "searchlight" means and includes any light exceeding 500-candle power, whether in one lamp or lantern, or in a series of lamps or lanterns used together and projected as one concentrated light, and which alters either in intensity, colour, or direction.

Advertising vans were so troublesome in London as to be prohibited in 1853; the "sandwich-man" has in the City of London and many towns been ousted from the pavement to the gutter, from the more crowded to the less crowded streets, and as the traffic problem in the great centres of population becomes more urgent, he will probably be altogether suppressed.

Hoardings are now so restricted by the London Building Acts that new hoardings cannot, except under special conditions, be erected exceeding 12 feet in height, and no existing hoardings can be increased in height so as to exceed that limit.

The huge signs which some advertisers, both in England and the United States, have placed in such positions as to mar the landscape, have so far aroused public antagonism that there is reason to hope that this form of nuisance will not increase.

In 1899 Edinburgh obtained effective powers of control over all sorts of advertising in public places, and this achievement has been followed by no little agitation in favour of a Parliamentary enactment which should once for all do away with the defacing of the landscape in any part of the United Kingdom. The society already mentioned has drafted a Rural Advertisements Bill in the following terms:—

(1) The power of a County Council to make bye-laws conferred by Section 16 of the Local Government Act 1888, shall, subject to the provisions of that section, extend to bye-laws:—

(a) For regulating or prohibiting the erection or placing of advertisements in or upon any arable or pasture land, woodland, garden, public park, common, or waste land, foreshore, or any inland or tidal water.

(b) For enforcing the removal of advertisements erected or placed in contravention of the bye-laws.

(c) For enforcing the removal, within a prescribed time—not being less than one year after the bye-laws come into operation—of any advertisements erected or placed before the making of the bye-laws in such a manner as would be in contravention of the bye-laws, if the same had been previously made.

(2) Nothing in any bye-law to be made under this Act shall affect any advertisement erected or placed either before or after the passing of this Act, upon any premises and relating solely to any trade, business, or business transaction carried on, or proposed to be carried on, or any entertainment or meeting held or to be held, upon or in relation to the said premises or to any property thereon.

(3) This Act shall not apply to or have any effect in the administrative county of London or in any [municipal] borough.

The English law with regard to posters has undergone very little change. The Metropolitan Police Act 1839 (2 & 3 Vict. cap. 47) first put a stop to unauthorized posting, and the Indecent Advertisements Act of 1889 (section 3) penalized the public exposure of any picture or printed or written matter of an indecent or obscene nature. But in general practice there is hardly any limitation to the size or character of poster advertisements, other than good taste and public opinion. On the other hand, public opinion is a somewhat vague entity, and there have been cases in which a conflict has arisen as to what public opinion really was, when its legally authorized exponent was in a position to insist on its own arbitrary definition. Such an instance occurred some few years ago in the case of a large poster issued by a well-known London music-hall. The Progressive majority on the London County Council, led by Mr M'Dougall, a well-known "purity" advocate, took exception to this poster, which represented a female gymnast in "tights" posed in what was doubtless intended for an alluring and attractive attitude; and, in spite of any argument, the fact remained that the decision as to renewing the license of this music-hall rested solely with the Council. In showing that it would have no hesitation in provoking even a charge of meddling prudery, the Council probably gave a salutary warning to people who were inclined to sail rather too near the wind. But in Great Britain and America, at all events (though a doubt may perhaps exist as to some Continental countries), the advertiser and the artist are restrained, not only by their own sense of propriety, but by fear of offending the sense of propriety in their customers.

Posters and placards in railway stations and upon public vehicles still embarrass the traveller who desires to find the name of a station or the destination of a vehicle. In respect of all these abuses it is a regrettable fact that unpopularity cannot be expected to deter the advertiser. If a name has once been fixed in the memory, it remains there long after the method of its impression has been forgotten, and the purpose of advertisements of the class under discussion is really no more than the fixing of a trade name in the mind. The average man or woman who goes into a shop to buy soap is more or less affected by a vague sense of antagonism toward the seller. There is a rudimentary feeling that even the most ordinary transaction of purchase brings into contact two minds actuated by diametrically opposed interests. The purchaser, who is not asking for a soap he has used before, has some hazy suspicion that the shopkeeper will try to sell, not the article best worth the price, but the article which leaves the largest margin of profit; and the purchaser imagines that he in some measure secures himself against a bad bargain when he exercises his authority by asking for some specific brand or make of the commodity he seeks. If he has seen any one soap so persistently advertised that his memory retains its name, he will ask for it, not because he has any reason to believe it to be better or cheaper than others, but simply because he baffles the shopkeeper, and assumes an authoritative attitude by exerting his own freedom of choice. This curious and obscure principle of action probably lies at the root of all poster advertising, for the poster does not set forth an argument as does the newspaper advertisement. It hardly attempts to reason with the reader, but merely impresses a name upon his memory. It is possible, by lavish advertising, to go so far in this direction that the trade-mark of a certain manufacturer becomes synonymous with the name of a commodity, so that when the consumer thinks of soap or asks for soap, his concept inevitably couples the maker's name with the word "soap" itself. In order that the poster may leave any impression upon his mind, it must of course first attract his attention. The assistance which the advertiser receives from the artist in this connexion is discussed in the article Posters.

Advertisement by circular.

The fact that the verb "to circularize" was first used in 1848, sufficiently indicates the very recent origin of the practice of plying possible purchasers with printed letters and pamphlets. The penny postage was not established in England until 1840; the halfpenny post for circulars was not introduced until 1855. In the United States a uniform rate of postage at two cents was not established until 1883. In both countries cheap postage and cheap printing have so greatly encouraged the use of circulars that the sort of people whom the advertiser desires to reach—those who have the most money to spend, and whose addresses, published in directories, indicate their prosperous condition—are overwhelmed by tradesmen's price-lists, appeals from charitable institutions, and other suggestions for the spending of money. The addressing of envelopes and enclosing of circulars is now a recognized industry in many large towns both in Great Britain and in the United States. It seems, however, to be the opinion of expert advertisers that what is called "general circularizing" is unprofitable, and that circulars should only be sent to persons who have peculiar reason to be interested by their specific subject-matter. It may be noted, as an instance of the assiduity with which specialized circularizing is pursued, that the announcement of a birth, marriage, or death in the newspapers serves to call forth a grotesque variety of circulars supposed to be adapted to the momentary needs of the recipient.

In concluding this review of methods of advertising, other than advertisements in periodical publications, we may add that the most extraordinary attempt at advertisement which is known to exist is to be found at the churchyard at Godalming, Surrey, where the following epitaph was placed upon a tombstone:—

Sacred
To the memory of
Nathaniel Godbold Esq.
Inventor & Proprietor
of that excellent medicine
The Vegetable Balsam
For the Cure of Consumptions & Asthmas.
He departed this Life
The 17th. day of Decr. 1799
Aged 69 years.
Hic Cineres, ubique Fama.

Advertising in periodical publications.

The preparation of advertisements for the periodical press has within the last twenty years or so become so important a task that a great number of writers and artists—many of the latter possessing considerable abilities—gain a livelihood from this pursuit. The ingenuity displayed in modern newspaper advertising is unquestionably due to American initiative. The English newspaper advertisement of twenty years ago consisted for the most part of the mere reiteration of a name. An advertiser who took a column's space, supplied enough matter to fill an inch, and ingenuously repeated his statement throughout the column. Such departures from this childlike method as were made were for the most part eccentric to the point of incoherence. It may, however, be said in defence of English advertisers, that newspaper publishers for a long time sternly discountenanced any attempt to render advertisements attractive. So long as an advertiser was rigidly confined to the ordinary single-column measure, and so long as he was forbidden to use anything but the smallest sort of type, there was very little opportunity for him to attract the reader's attention. The newspaper publisher must always remember that the public buy a newspaper for the sake of the news, not for the sake of the advertisements, and that if the advertisements are relegated to a position and a scope, in respect of display, so inferior that they may be overlooked, the advertiser cannot afford to bear his share of the cost of publication. Of late *The Times*, followed by almost all newspapers in the United Kingdom, has given the advertiser as great a degree of liberty as he really needs, and many experienced advertisers in America incline to the belief that the larger license accorded to American advertisers defeats its own ends. The truth would seem to be that the advertiser will always demand, and may fairly expect, the right to make his space as fantastic in appearance as that allotted to the editor. When some American editors see fit to print a headline in letters as large as a man's hand, and to begin half-a-dozen different articles on the first page of a newspaper, continuing one on page 2, another on page 4, and another on page 6, to the bewilderment of the reader, it can hardly be expected that the American advertiser should submit to any very strict code of decorum. The subject of the relation between a newspaper proprietor and his advertisers cannot be dismissed without reference to the notable independence of advertisers' influence, which English and American newspaper proprietors authorize their editors to display. Whenever an insurance company or a bank goes wrong, the cry is raised that all the editors in Christendom had known for years that the directors were imbeciles and rogues, but had conspired to keep mute for the sake of an occasional advertisement. When the British public persisted, not long ago, in paying premium prices for the shares of over-capitalized companies, the crash had no sooner come than the newspapers were accused of having puffed promotions for the sake of the money received for publishing prospectuses. As a matter of fact, in the case of the best dailies in England and America, the editor does not stand at all in awe of the advertiser, and time after time the Money Article has ruthlessly attacked a promotion of which the prospectus appeared in the very same issue. It is indeed to the interest of the advertiser, as well as to the interest of the reader, that this independence should be preserved, for the worth of any journal as an advertising medium depends upon its possessing a *bonâ-fide* circulation among persons who believe it to be a serious and honestly-conducted newspaper. All advertisers know that the minor weeklies, which contain nothing but trade puffs, and are scattered broadcast among people who pay nothing for their copies, are absolutely worthless from the advertiser's point of view. The most striking difference between the periodical press of Great Britain and that of America is, that in the former country the magazines and reviews play but a secondary rôle, while in the United States the three or four monthlies possessing the largest circulation are of the very first importance as advertising mediums. One reason for this is that the advertisements in an American magazine are printed on as good paper, and printed with as great care, as any other part of the contents. There are probably very few among American magazine readers who do not habitually look through the advertising pages, with the certainty that they will be entertained by the beauty of the advertiser's illustrations and the quaint curtness of his phrases. Another reason is that the American monthly magazine goes to all parts of the United States, while, owing to the time required for long journeys on even the swiftest trains, no American daily paper can have so general a circulation as *The Times* in the United Kingdom. In comparison with points on the Pacific coast, Chicago does not seem far from New York, yet, with the exception of one frenzied and altogether unsuccessful attempt, no New York daily has ever attempted to force a circulation in Chicago. The American advertiser would, therefore, have to spend money on a great number of daily papers in order to reach as widespread a public as one successful magazine offers him.

There is reason to believe that the English magazine publishers have erred gravely in taking what are known in the trade as "insets," consisting of separate cards or sheets printed at the advertiser's cost, and accepted by the publisher at a specific charge for every thousand copies. This system of insetting has the grave inconvenience that the advertiser finds himself compelled to print as many insets as the publisher asserts that he can use. The publisher, on the other hand, is somewhat at the mercy of too enthusiastic agents and employés, who estimate over-confidently the edition of the periodical which will probably be printed for a certain month, and advertisers have had reason to fear that many of their insets were wasted. The added weight and bulk of the insets cause inconvenience and expense to the newsdealer, as two or three insets printed upon cardboard are equivalent to at least sixteen additional pages. Some newsdealers have further complicated the inset question by threatening to remove insets unless special tribute be paid to them; and with all these difficulties to be considered, many magazine publishers have seriously considered the advisability of altogether discontinuing the practice of taking insets, and of confining their advertisements to the sheets they themselves print. In connexion with this subject, it may be added that many readers habitually shake loose bills out of a magazine before they begin to turn the pages, and that railway stations, railway carriages, and even public streets, are thus littered with trampled and muddy advertisements. The old practice of distributing handbills in the streets is dying a natural death, more or less hastened by local bye-laws, and when the loose bills in magazines and cheap novels have ceased to exist no one will be the loser.

Advertisements in the weekly press are on the whole more successful in England than in America. A few American weeklies cope successfully with the increasing competition of the huge Sunday editions of American daily papers. But even the most successful among them —a paper for boys—has hardly attained the prosperity of some among its English contemporaries in the field of weekly journalism.

The merchant who turns to these pages for practical suggestions concerning the advertising of his own business, can be given no better advice than to betake himself to an established advertising agent of good repute, and be guided by his counsels. The chief part that he can himself play with advantage is to note from day to day whether the agent is obtaining advantageous positions for his announcements. Every advertiser will naturally prefer a right-hand page to a left-hand page, and the right side of the page to the left side of the page; while the advertiser who most indefatigably urges his claims upon the agent will, in the long run, obtain the largest share of the favours to be distributed. To the merchant who inclines to consider advertising in connexion with the broader aspects of his calling, it may be suggested that a new channel of trade demands very serious attention. What is called in England "postal trade," and in America "mail order business," is growing very rapidly. Small dealers in both countries have complained very bitterly of the competition they suffer from the general dealers and from stores made up of departments which, under one roof, offer to the consumer every imaginable sort of merchandise. This general trading, which, on the one hand, seriously threatens the small trader, and on the other hand offers greater possibilities of profit to the proportionately small number of persons who can undertake business on so large a scale, becomes infinitely more formidable when the general dealer endeavours not only to attract the trade of a town, but to make his place of business a centre from which he distributes by post his goods to remote parts of the country. In America, where the weight of parcels carried by post is limited to four pounds, and where the private carrying companies are forced to charge a very much higher rate for carriage from New York to California than for shorter distances, the centralization of trade is necessarily limited; but it is no secret that, at the present moment, persons residing in those parts of the United Kingdom most remote from London habitually avail themselves of the English parcel post, which carries packages up to eleven pounds, in order to procure a great part of their household supplies direct from general dealers in London. A trading company, which conducts its operations upon such a scale as this, can afford to spend an almost unlimited sum in advertising throughout the United Kingdom, and even the trader who offers only one specific class of merchandise is beginning to recognize the possibility of appealing to the whole country.

With regard to the literature of advertising, it need only be added that, in addition to the historical article in the *Edinburgh Review* for February 1843, already mentioned, and that in the *Quarterly Review* for June 1855, the advertisers' handbooks, issued by the leading advertising agents, will be found to contain practical information of great use to the advertiser. (H. R. H.*)

Adye, Sir John Miller (1819-1900), British general and colonel commandant royal artillery, son of Major James P. Adye, royal artillery, was born at Sevenoaks, Kent, on the 1st of November 1819. He entered the royal artillery in 1836, was promoted captain in 1846, and served throughout the Crimean War of 1854-56 as brigade-major and assistant adjutant-general of artillery (medal with four clasps, Turkish medal, third class of the Legion of Honour, fourth class of the Medjidie, C.B., and brevets of major and lieut.-colonel). In the Indian Mutiny he served on the staff in a similar capacity (medal). Promoted brevet-colonel in 1860, he was specially employed in 1863 in the N.W. frontier of India campaign (medal with clasp), and was deputy adjutant-general, Bengal, from 1863 to 1866, when he returned home. From 1870 to 1875 Adye was director of artillery and stores at the War Office, where his influence was used to prevent the introduction of breech-loading ordnance. He was made a K.C.B. in 1873, having taken an active part in Mr Cardwell's army reform. He was promoted to be major-general and appointed governor of the Royal Military Academy at Woolwich in 1875, and surveyor-general of the ordnance in 1880. In 1882 he was chief of the staff and second in command of the expedition to Egypt, and served throughout the campaign (medal with clasp, bronze star, second class of the Medjidie, G.C.B., and thanks of Parliament). He held the government of Gibraltar from 1883 to 1886. Promoted lieut.-general in 1879, and general and colonel commandant of royal artillery in 1884, he retired in 1886. He unsuccessfully contested the Parliamentary representation of Bath in the Liberal interest in 1892. He died on 26th August 1900, when on a visit to Lord Armstrong in Northumberland. He was the author of *A Review of the Crimean War; The Defence of Cawnpore; A Frontier Campaign in Afghanistan; Recollections of a Military Life;* and *Indian Frontier Policy.*

(R. H. V.)

Ægades, or Ægates, in Italian *Egadi*, a group of islands lying W. of Sicily and belonging to the prov. of Trapani, the largest being Marittimo, the ancient *Hiera*, rising to 2244 feet in Mount Falcone; Levanzo, the ancient *Phorbantia*, rising to 951 feet; and Favignana, the ancient *Ægusa*; altitude, 1070 feet; area of all, 70 square miles. Total population (1901), 6419. They carry on tunny and sponge fishing. Marittimo has a state prison, and produces honey and capers. Chief town and port, Favignana; cleared annually by some 400 vessels of about 100,000 tons. Population (1901), 5001.

Aeltre, a town of Belgium, in the province of East Flanders, 12 miles W. by N. of Ghent by rail, near the Ghent and Bruges canal. Its trade is mainly in linen and wood. Population (1900), 6261; communal (1880), 7020; (1897), 7174.

Aeronautics.—Notwithstanding the prejudice consequent on past failures and upon premature assertion of impending success, the advance in aeronautics since the publication of the ninth edition of this work has been greater and more rapid than at any time in history. This advance has consisted in:—(1) The evolution of light motors; (2) the elucidation of natural laws; (3) many partially successful experiments. Electric, steam, gas, or petroleum engines have been reduced to a fraction of their former weights, formerly-accepted data for computations have been quite superseded, and numerous experiments have been made.

Balloons.

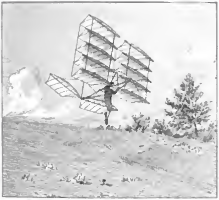
Few scientific men have imitated Mr Glaisher in making high ascents for meteorological observations. Sivel, Crocé-Spinelli, and Tissandier, who reached 27,950 feet on 15th April 1875, were asphyxiated, and only Tissandier came down alive. This put a stop to such attempts for a time; but Gross and Berson attained 25,840 feet on 11th May 1894, Berson reached 29,740 feet on 4th December 1894, recording a temperature of −54° F., and Berson and Spencer are stated by the latter to have attained 27,500 feet on 15th September 1898, the thermometer registering −29° F. The personal danger attending such ascents led Hermite and Besançon to inaugurate in November 1892 the sending up of unmounted balloons (Ballons Sondes), equipped with automatic recording instruments (see Meteorology). On 11th July 1897, Andrée, Strindberg, and Frankel ascended from Spitzbergen in a daring attempt to reach the North Pole by balloon. One carrier pigeon, apparently liberated forty-eight hours after the start, was shot, and two floating buoys with messages were found; but nothing more has been heard of the explorers.

From the very first invention of balloons the problem has been how to navigate them by propulsion. General Meusnier proposed an elongated balloon in 1784. It was experimented on by Robert Brothers, who made two ascensions and claimed to have obtained a deviation of 22° from the direction of a light wind by means of aerial oars worked by hand. The relative speed was probably about 3 miles an hour, and it was so evident that a very much more energetic light motor than any then known was required to stem ordinary winds that nothing more was attempted till 1852, when Giffard ascended with a steam-engine of then unprecedented lightness. The subjoined table exhibits the subsequent progress which has been made:—

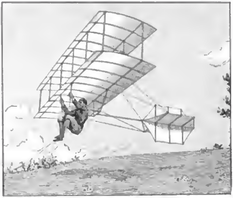
Experiments with Dirigible Balloons.

Year.	Inventor.	Length.	Diameter.	Contents.	Lifting Capacity.	Weight of Balloon.	Weight of Motor.	H.-P.	Speed per hour.
		Ft.	Ft.	Cub. ft.	lb.	lb.	lb.		Miles.
1852	Giffard	144	39	88,300	3,978	2,794	462	3·0	6·71
1872	De Lôme	118	49	120,088	8,358	4,728	2000	0·8	6·26
1884	Tissandier	92	30	37,439	2,728	933	616	1·5	7·82
1885	Renard and Krebs	165	27	65,836	4,402	2,449	1174	9·0	14·00
1897	Wolfert	92	28	..	..	..	..	8·0	..
1897	Schwarz	157	46 39	130,500	8,183	6,800	800?	16·0	17·00
1900	Zeppelin	429	39	400,000	25,000	19,000	1500	32·0	18·00

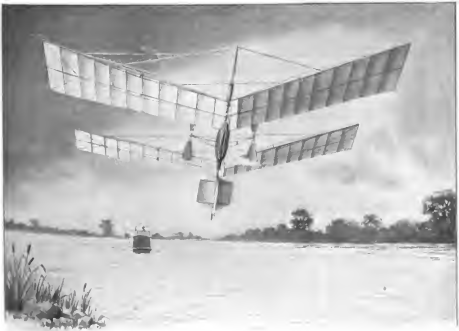
Giffard, the future inventor of the injector, devised a steam-engine weighing, with fuel and water for one hour, 154 lb per horse-power, and was bold enough to employ it in proximity to a balloon inflated with coal gas. He was not able to stem a medium wind, but attained some deviation. He repeated the experiment in 1855 with a more elongated spindle, which proved unstable and dangerous. During the siege of Paris the Government decided to build a navigable balloon, and entrusted the work to the chief naval constructor, Dupuy de Lome. He went into the subject very carefully, made estimates of all the strains, resistances, and speeds, and tested the balloon in 1872. Deviations of 12° were obtained from the course of a wind blowing 27 to 37 miles per hour. The screw propeller was driven by eight labourers, a steam-engine being deemed too dangerous: but it was estimated that had one been used, weighing as much as the men, the speed would have been doubled. Tissandier and his brother applied an electric motor, lighter than any previously built, to a spindle-shaped balloon, and went up twice in 1883 and 1884. On the latter occasion he stemmed a wind of 7 miles per hour. The brothers abandoned these experiments, which had been carried on at their own expense, when the French War Department took up the problem. Renard and Krebs, the officers in charge of the War Aeronautical Department at Meudon, built and experimented with in 1884 and 1885 the fusiform balloon "La France," in which the "master" or maximum section was about one-quarter of the distance from the stem. The propelling screw was at the front of the car and driven by an electric motor of unprecedented lightness. Seven ascents were made on very calm days, a maximum speed of 14 miles an hour was obtained, and the balloon returned to its starting-point on five of the seven occasions. Since then another balloon has been constructed, said to be capable of a speed of 22 to 28 miles per hour, with a different motor; but no tests are known to the public and the secrets of this war engine



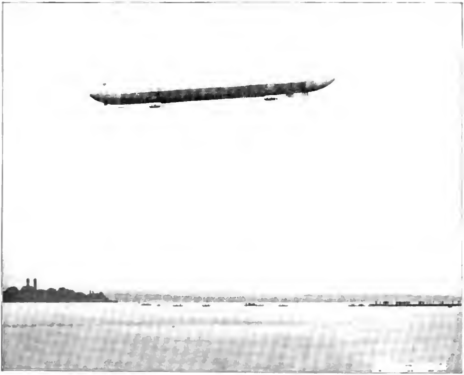
Multiple-wing Gliding Machine.



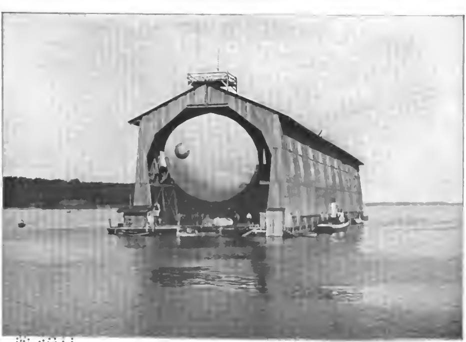
Chanute's Gliding Machine.



Langley's Aerodrome.



Zeppelin's Airship in Flight.



Zeppelin's Airship in its Shed.
(From Photographs by F. Schwarzenbach, Kreuzlingen, Switzerland.)

are carefully guarded. After many years of experiment Dr Wölfert built and experimented with in Berlin, in 1897, a cigar-shaped balloon driven by a gasoline motor. An explosion took place in the air, the balloon fell, and Dr Wölfert and his assistant were killed. It was also in 1897 that an aluminium balloon was built from the designs of D. Schwarz (then deceased) and tested in Berlin. It was driven by a Daimler benzine motor, and attained a greater speed than "La France"; but a driving belt slipped off its pulley, and in coming down the balloon was injured beyond repair. From 1897 to 1900 Count Zeppelin, of the German army, was engaged in constructing an immense balloon, truly an air ship, of most careful and most intelligent design, to carry five men. It was first tested in June 1900, when it attained a speed of 18 miles an hour and travelled a distance of 3½ miles before an accident to the steering gear necessitated the discontinuance of the experiment. In 1901 M. Santos Dumont carried out some more or less successful experiments with a dirigible balloon in Paris.

The principles which govern the design of the dirigible balloon may be said to have been evolved. As the lifting power grows as the cube of the dimensions, and the resistance approximately as the square, the advantage lies with the larger sizes of balloons, as of ocean steamers, up to the limits within which they may be found practicable. Count Zeppelin may have reached the limit as to practicable size. He has gained an advantage by attaching his propellers to the balloon, instead of to the car as heretofore; but this requires a rigid framework and a great increase of weight. Le Compagnon endeavoured, in 1892, to substitute flapping wings for rotary propellers, as the former can be suspended nearer the centre of resistance. Danilewsky followed him in 1898 and 1899, but thus far without remarkable results. Dupuy de Lôme was the first to estimate in detail the resistances to balloon propulsion, but experiment showed that in the aggregate they were greater than he calculated. Renard and Krebs also found that their computed resistances were largely exceeded, and after revising the results they gave the formula $R=0·01685\ D^2V^2$, R being the resistance in kilograms, D the diameter in metres, and V the velocity in metres per second. Reduced to British measures, in pounds, feet, and miles per hour, $R=0·0006876\ D^2V^2$, which is somewhat in excess of the formula computed by Dr Pole from De Lôme's experiments. The above coefficient applies only to the shape and rigging of the balloon "La France," and combines all resistances into one equivalent, which is equal to that of a flat plane 18 per cent. of the "master section." This coefficient may perhaps hereafter be reduced by one-half through a better form of hull and car, more like a fish than a spindle, by diminished sections of suspension lines and net, and by placing the propeller at the centre of resistance. To compute the results to be expected from new projects, it will be preferable to estimate the resistances in detail. The following table shows how this was done by De Lôme, and the probable corrections which should have been made by him:—

Resistances—De Lôme's Balloon.

Computed by De Lôme. V=2·22 m. per sec.					More Probable Values. V=2·82 m. per sec.		
Part.	Area, Sq. Metre.	Coefficient.	Air Pressure.	Resistance, Kg.	Coefficient.	Air Pressure.	Resistance, Kg.
Hull, without net.	172·96	1/30	0·665	3·830	1/15	0·875	10·091
Car	3·25	1/5	,,	0·432	1/5	,,	0·569
Men's bodies	3·00	1/5	,,	0·400	1/2	,,	1·312
Gas tubes	6·40	1/5	,,	0·850	1/2	,,	2·750
Small cords	10·00	1/2	,,	3·325	1/2	,,	4·375
Large cords	9·90	1/3	,,	2·194	1/3	,,	2·887
				11·031			21·984

When the resistances have been reduced to the lowest possible minimum by careful design, the attainable speed will depend upon the efficiency of the propeller and the relative lightness of the motor. It seems not unlikely that 30 miles per hour can be attained in the near future; but the commercial uses will be small, as the balloons must remain housed when the wind aloft is brisk. The sizes will be great and costly, the loads small, and the craft frail and short-lived, yet dirigible balloons constitute the proper type for Governments to evolve, until they are superseded by efficient flying machines.

Flying machines.

While the flying machine is still inferior to the balloon in performance and safety, it has made more progress since 1888 than during the preceding three centuries. Investigation has turned from flapping wings and from sustaining screws to the aeroplane type, and encouraging results have been obtained not only with models but with full-sized machines. The flights have been very short and hazardous, but the speeds have been much greater than with balloons. The danger involved in the proximity of fire to gas being absent, Maxim, Langley, Ader, and others have produced steam motors weighing 10 lb or less per horse-power. This, it is true, is exclusive of fuel and water, and the engines work nearly to the limits of endurance; but the automobile industry is developing gasoline motors which are nearly as light, and these may prove better adapted to aerial propulsion. Knowledge has been greatly increased as to the laws of flight. Professor Marey has furnished new data concerning bird locomotion, and Professor Langley has elucidated the problem of air reactions on oblique planes. Physicists still computed, down to 1891, the normal pressures upon oblique planes as varying in the ratio of the square of the sine of the angle of incidence or, at best, in the ratio of the sine of that angle. Langley showed, by extensive experiments, that this normal had nearly twice the assigned value, and that Duchemin's empirical formula

$$N = P\frac{2\sin\alpha}{1+\sin^2\alpha}$$

which was proposed about 1838 but not adopted, was approximately correct for oblique planes. More than this, Lilienthal showed, about the same time, that concave bird-like surfaces afforded from three to seven times as much support as planes at acute angles of incidence, and gave also a small propelling component, so that former views and modes of calculating the surfaces and power required for flight have been quite revolutionized. Experiments have therefore been more intelligent and more successful than

Principal Experiments with Flying Machines.

Year.	Inventor.	Tip to Tip.	Surface.	Weight.	Pounds per square foot.	Speed per hour.	Maximum Flight.	Motor.	Horse-Power.	Pounds sustained per Horse-Power.
		Ft.	Sq. ft.	lb.		Mls.	Ft.			
1879	Tatin.	6·2	7·5	3·85	0·51	18	100?	Compressed air	0·03	110?
1885 1889	Hargrave (No. 16)	5·5	26·0	5·00	0·19	10	343	,,	0·06	79
1893	Phillips	22·0	136·0	402·00	3·00	28	500?	Steam	5·6	72?
1894	Maxim*	50·0	4000·0	8000·00	2·00	36	300?	,,	363·00	22
1896	Langley	12·0	70·0	30·00	0·43	24	4000	,,	1·00	30
1897	Tatin and Richet	21·0	86·0	72·00	0·83	40	460	,,	1·33	55
1897	Ader*	49·0	270·0	1100·00	4·00	50?	100?	,,	40·00	27
1895	Lilienthal*	23·0	151·0	220·00	1·46	23	1200	Gravity	2·00	110
1896	Pilcher*	23·0	170·0	200·00	1·17	25	900	,,	2·00	100
1896	Chanute*[1]	16·0	135·0	178·00	1·31	22	800	,,	2·00	89

---

[1] The pounds sustained per horse-power in the last three experiments will probably be reduced one-half when an artificial motor is substituted for gravity.

ever before. It can no longer be said that men have never flown through the air. The preceding table (p.101) exhibits the more important performances, and attention is called to the columns of pounds imposed per square foot, to the resulting speed required for support, and to the pounds sustained per horse-power (the apparatus marked thus * carried a man or men).

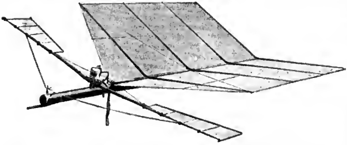


Fig. 1.—General appearance of Hargrave's flying machine. (From *Engineering*.)

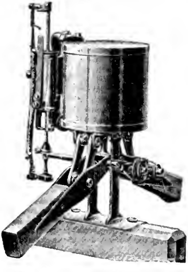


Fig. 2.—Engine for Hargrave's flying machine. From *Engineering*.)

The first aeroplane of Tatin (1879) consisted of a pair of flat wings and a tail, traction being obtained from two screw propellers at the front. The horse-power was arrived at by allowing 25 to 30 per cent. of that shown by the indicator for the compressed air. When Tatin and Richet substituted steam in 1897 they only sustained about half as many pounds per h.p.; but this was still very good. The equilibrium was defective and greatly shortened the possible flights. A score of different models have been produced by Hargrave, of New South Wales, since 1885. His No. 16 has been selected for the table given. It consisted in a body plane of kite shape, propelled by a pair of flapping vanes at the front (Figs. 1, 2, 3). Hargrave built a number of steam-engines weighing about 10 lb per h.p., but found such difficulties that he turned his attention to oil motors. He advocates large surfaces and low speeds, and hopes to maintain those proportions by suspending a motor and propellers from a tandem team of the "Cellular Kites" which he has invented, and with which he has been lifted from the ground. The apparatus of Phillips resembles a Venetian blind. The slats are of wood, convex on the upper surface and concave beneath. The lift is apparently very good, but the stability is defective. After many preliminary experiments on air reactions, Maxim tested, in 1894, a very large flying machine, a marvel of ingenuity and mechanical skill, carrying three men. It consisted in a combination of superimposed aeroplanes, driven by two screw propellers, which were rotated by a compound steam-engine of 363 h.p., weighing with its adjuncts some 10 lb per h.p. The apparatus gathered speed on a railway track, and demonstrated that it could lift much more than its own weight; but the pounds sustained per h.p. were less than was expected, probably by reason of head resistance caused by many guy wires, and the stability was inadequate. After publishing his *Experiments in Aerodynamics* in 1891, Langley produced in 1896 a steam-driven flying model, with which he obtained the longest flights ever known. The apparatus consisted of two pairs of wings and a tail, with two screw propellers, driven by a high pressure steam-engine of 1 h.p. weighing but 7 lb. The longest flight was over ¾ of a mile, and the apparatus alighted safely on each of the three flights made. The lift per horse-power was low, for a variety of reasons, but the stability was good. After having tested, in 1872 and 1891, two full-sized flying machines, producing indifferent results, Ader built, in 1897, a third apparatus with funds furnished by the French Government. This reproduced the structure of a bird with almost servile imitation, save that traction was obtained by two screw pro-

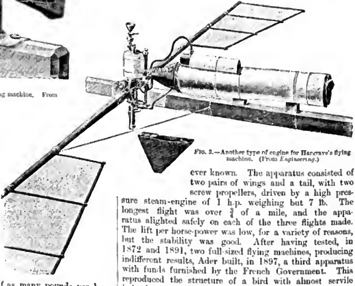


Fig. 3.—Another type of engine for Hargrave's flying machine. (From *Engineering*.)

Santos Dumont's Balloon in Flight.

(From a Photograph by J. Giletta, Nice.)

Santos-Dumont's Balloon, Rear View, showing Rudder and Propeller.

(From a Photograph by Otto Barra, Paris.)

pellers (Figs 4, 5). The steam-engines weighed about 7 lb per h.p., but the equilibrium of the apparatus was defective. To Lilienthal belongs the double credit of demonstrating the superiority of arched surfaces over planes, and of reducing gliding flight to regular practice. He made over 2000 glides safely, using gravity as a motive-power, with various forms of apparatus, consisting of concave bat-like wings, in some cases superimposed. It was with a machine of the latter type that he was upset by a sudden gust of wind and killed in 1896. Pilcher improved somewhat upon Lilienthal's apparatus, but used the same general method of restoring the balance, when endangered, by shifting the weight of the operator's body. He made several hundred glides in safety, until he too was upset by a gust of wind and killed in 1899. Chanute confined his endeavours exclusively to the evolution of automatic stability, and made the surfaces movable instead of the man. He obtained over 1000 glides without accident with two different types of apparatus. The last three experimenters have claimed that it is not impossible for man to imitate the soaring flight of certain birds, wherein support and propulsion are obtained from the wind alone under certain favourable conditions.

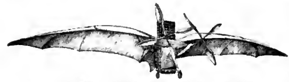


FIG. 4.—Ader's "Avion" in position for flight. (From *The Scientific American*.)

The very first essential for success is safety, which will probably only be attained with automatic stability, and the foregoing account indicates that it is for lack of this that all the experiments have shown such slight success. Safety and stability are therefore to be sought first. The underlying principle is that the centre of gravity shall at all times be on the same vertical line as the centre of pressure. The latter varies with the angle of incidence. For square planes it moves approximately, as expressed by Joessel's formula: $C = (0{\cdot}2 + 0{\cdot}3 \sin a)L$, in which C is the distance from the front edge, L the length fore and aft, and a the angle of incidence. The movement is different on concave surfaces, but has not been formulated. The term *Aeroplane* is understood to apply to flat sustaining surfaces, but experiment indicates that arched surfaces are more efficient. Langley has proposed the word *Aerodrome*, which seems the preferable term for apparatus with wing-like surfaces. This type is the one which results point to as the proper type for further experiments. With this it seems probable that, with well-designed apparatus, 40 to 50 lb can be sustained per indicated h.p., or about twice that quantity per resistance or "thrust" h.p., and that some 30 or 40 per cent. of the weight can be devoted to the machinery, thus requiring motors, with their propellers, shafting, supplies, &c., weighing less than 20 lb per h.p. The problem, then, is how they should be designed. The knowledge evolved within the last few years has at last made it practicable to give some data for calculating the effects to be expected, with some confidence that they will not be far wrong. It is evident that an apparatus must be designed to be as light as possible, and also to reduce to a minimum all resistances to propulsion. This being kept in view, the strength and consequent section required for each member may be calculated by the methods employed in proportioning bridges, with the difference that the support (from air pressure) will be considered as uniformly distributed, and the load as concentrated at one or more points. Smaller factors of safety may also have to be used. Knowing the sections required and unit weights of the materials to be employed, the weight of each part can be computed. If a model has been made to absolutely exact scale, the weight of the full-sized apparatus may approximately be ascertained by the formula

$$W' = W\sqrt{\left(\frac{S'}{S}\right)^3},$$

in which W is the weight of the model, S its surface, and W' and S' the weight and surface of the intended apparatus. Thus if the model has been made one-quarter size in its homologous dimensions, the supporting surfaces will be sixteen times, and the total weight sixty-four times those of the model. The weight and the surface being determined, the three most important things to know are the angle of incidence, the "lift," and the required speed. The fundamental formula for rectangular air pressure is well known: $P = KV^2S$, in which P is the rectangular normal pressure, in pounds or kilograms, K a coefficient, (0·0049 for British, and 0·11 for metric measures), V the velocity in miles per hour or in metres per second, and S the surface in square feet or in square metres. The normal on oblique surfaces, at various angles of incidence, is given by the formula $P = KV^2S\eta$, which

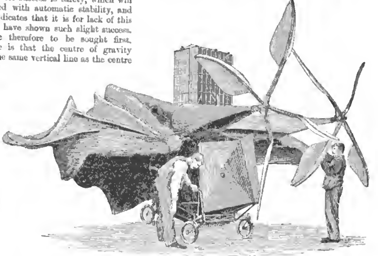


FIG. 5.—Ader's "Avion" with the wings folded. (From *The Scientific American*.)

latter factor is given both for planes and for arched surfaces in the subjoined table:—

Percentages of Air Pressure at Various Angles of Incidence.

PLANES: DUCHEMIN FORMULA. $N = P\frac{2\sin\alpha}{1+\sin^2\alpha}$				WINGS: LILIENTHAL. Concavity 1 in 12.			
Angle. α	Normal. η	Lift. $\eta\cos\alpha$	Drift. $\eta\sin\alpha$	Normal. η	Lift. $\eta\cos\alpha$	Drift. $\eta\sin\alpha$	Tangential force. a
−9°				0·0	0·0	0·0	+0·070
−8°				0·040	0·0396	−0·0055	+0·067
−7°				0·080	0·0741	−0·0097	+0·064
−6°				0·120	0·1193	−0·0125	+0·060
−5°				0·160	0·1591	−0·0139	+0·055
−4°				0·200	0·1995	−0·0139	+0·049
−3°				0·242	0·2416	−0·0126	+0·043
−2°				0·286	0·2858	−0·0100	+0·037
−1°				0·332	0·3318	−0·0058	+0·031
0°	0·0	0·0	0·0	0·381	0·3810	−0·0	+0·024
+1°	0·035	0·035	0·000611	0·434	0·434	+0·0075	+0·016
+2°	0·070	0·070	0·00244	0·489	0·489	+0·0170	+0·008
+3°	0·104	0·104	0·00543	0·546	0·545	+0·0285	0·0
+4°	0·139	0·139	0·0097	0·600	0·597	+0·0418	−0·007
+5°	0·174	0·173	0·0152	0·650	0·647	+0·0566	−0·014
+6°	0·207	0·206	0·0217	0·696	0·692	+0·0727	−0·021
+7°	0·210	0·238	0·0293	0·737	0·731	+0·0898	−0·028
+8°	0·273	0·270	0·0381	0·771	0·763	+0·1072	−0·035
+9°	0·305	0·300	0·0477	0·800	0·790	+0·1251	−0·042
10°	0·337	0·332	0·0585	0·825	0·812	+0·1432	−0·050
11°	0·369	0·362	0·0702	0·846	0·830	+0·1814	−0·058
12°	0·398	0·390	0·0828	0·864	0·845	+0·1803	−0·064
13°	0·431	0·419	0·0971	0·879	0·856	+0·1976	−0·070
14°	0·457	0·443	0·1155	0·891	0·864	+0·2156	−0·074
15°	0·486	0·468	0·1240	0·901	0·870	+0·2332	−0·076

The sustaining power, or "lift," which in horizontal flight must be equal to the weight, can be calculated by the formula: $L = KV^2S\eta\cos\alpha$, or the factor may be taken direct from the table, in which the "lift" and the "drift" have been obtained by multiplying the normal η by the cosine and sine of the angle. The last column shows the tangential pressure on concave surfaces which Lilienthal found to possess a propelling component between 3° and 32°, and therefore to be negative to the relative wind. Former modes of computation indicated angles of 10° to 15° as necessary for support with planes. These were prohibitory in consequence of the great "drift"; but the present data indicate that, with concave surfaces, angles of 2° to 5° will produce adequate "lift." To compute the latter the angle at which the wings are to be set must first be assumed, and that of +3° will generally be found preferable. Then the required velocity is next to be computed by the formula:

$$V = \sqrt{\frac{L}{KS\eta\cos\alpha}}\ ,$$

or for concave wings at +3°:

$$V = \sqrt{\frac{W}{0{\cdot}545KS}}.$$

Having thus determined the weight, the surface, the angle of incidence, and the required speed for horizontal support, the next step is to calculate the power required. This is best accomplished by first obtaining the total resistances, which consist of the "drift" and of the head resistances due to the hull and framing. The latter are arrived at preferably by making a tabular statement similar to that shown under the head of balloons, showing all the spars and parts offering head resistance, and applying to each the coefficient appropriate to its "master section," as ascertained by experiment. Thus is obtained an "equivalent area" of resistance, which is to be multiplied by the wind pressure due to the speed. Care must be taken to resolve all the resistances at their proper angle of application, and to subtract or add the tangential force, which consists in the surface S, multiplied by the wind pressure, and by the factor in the table, which is, however, 0 for 3° and 32°, but positive or negative at other angles. When the aggregate resistances are known, the "thrust h.p." required is obtained by multiplying the resistance by the speed, and then allowing for mechanical losses in the motor and propeller, which losses will generally be 50 per cent. of indicated h.p. Close approximations are obtained by the above method when applied to full-sized apparatus. The following example will make the process clearer. The weight to be carried by an apparatus was 189 lb on concave wings of 143·5 sq. ft. area, set at a positive angle of 3°. There were in addition rear wings of 29·5 sq. ft., set at a negative angle of 3°, carrying no weight; hence, $L = 189 = 0{\cdot}005 \times V^2 \times 143{\cdot}5 \times 0{\cdot}545$. Whence $V = \sqrt{\frac{189}{0{\cdot}005 \times 143{\cdot}5 \times 0{\cdot}545}} = 22$ miles per hour, at which the air pressure would be 2·42 lb per sq. ft. The area of spars and man was 17·86 sq. ft., reduced by various coefficients to an "equivalent surface" of 11·70 sq. ft., so that the resistances were:—

Drift front wings, 143·5 × 0·0285 × 2·42 . .	= 9·90 lb.
" rear wings, 29·5 × (0·043 − 0·242 × 0·0523) × 2·42	= 2·17 "
Tangential force at 3°	= 0·00 "
Head resistance, 11·70 × 2·42	= 28·31 "
Total resistance	= 40·38 lb.

Speed 22 miles per hour. Power $= \frac{40{\cdot}38 \times 22}{375} = 2{\cdot}36$ h.p. for the "thrust" or 4·72 h.p. for the motor. The weight being 189 lb, and the resistance 40·38 lb, the gliding angle of descent was: $\frac{40{\cdot}38}{189}$ = tangent of 12°, which was verified by many experiments.

The following expressions, some of which have been given in the text, will be found useful in computing such projects, with the aid of the table above given:—

1. Wind force, $F = KV^2$
2. Pressure, $P = KV^2S$.
3. Velocity, $V = \sqrt{\frac{W}{KS\eta\cos\alpha}}$
4. Surface S varies as $\frac{1}{V^2}$
5. Normal, $N = KSV^2\eta$.
6. Lift, $L = KSV^2\eta\cos\alpha$.
7. Weight, $W = L = N\cos\alpha$.
8. Drift, $D = KSV^2\eta\sin\alpha$.
9. Head area E, get an equivalent.
10. Head resistance, $H = EF$.
11. Tangential force, $T = Pa$.
12. Resistance, $R = D + H \pm T$.
13. Ft. lb, $M = RV$.
14. Thrust, h.p., $= \frac{RV}{\text{factor}}$.

(O. C.)

Æther.—In the mechanical processes which we can experimentally modify at will, and which therefore we learn to apprehend with greatest fulness, whenever an effect on a body B is in causal connexion with a process instituted in another body A, it is usually possible to discover a mechanical connexion between the two bodies which allows the influence of A to be traced all the way across the intervening region. The question thus arises whether, in electric attractions across apparently empty space and in gravitational attraction across the celestial regions, we are invited or required to make search for some similar method of continuous transmission of the physical effect, or whether we should rest content with an exact knowledge of the laws according to which one body affects mechanically another body at a distance. The view that our knowledge in such cases may be completely represented by means of laws of action at a distance, expressible in terms of the positions (and possibly motions) of the interacting bodies without taking any heed of the intervening space, belongs to modern times. It could hardly have been thought of before Sir Isaac

Newton's discovery of the actual facts regarding universal gravitation. Although, however, gravitation has formed the most perfect instance of an influence completely expressible, up to the most extreme refinement of accuracy, in terms of laws of direct action across space, yet, as is well known, the author of this ideally simple and perfect theory held the view that it is not possible to conceive of direct mechanical action independent of means of transmission. In this belief he differed from his pupil Cotes, and from most of the great mathematical astronomers of the 18th century, who worked out in detail the task sketched by the genius of Newton. They were content with a knowledge of the truth of the principle of gravitation; instead of essaying to explain it further by the properties of a transmitting medium, they in fact modelled the whole of their natural philosophy on that principle, and tried to express all kinds of material interaction in terms of laws of direct mechanical attraction across space. If material systems are constituted of discrete atoms, separated from each other by many times the diameter of any of them, this simple plan of exhibiting their interactions in terms of direct forces between them would indeed be exact enough to apply to a wide range of questions, provided we could be certain that the laws of the forces depended only on the positions and not also on the motions of the atoms. The most important example of its successful application has been the theory of capillary action elaborated by Laplace; though even here it appeared, in the hands of Young, and in complete fulness afterwards in those of Gauss, that the definite results attainable by the hypothesis of mutual atomic attractions really reposed on much wider and less special principles—those, namely, connected with the modern doctrine of energy.

Idea of an Æther.—The wider view, according to which the hypothesis of direct transmission of physical influences expresses only part of the facts, is that all space is filled with physical activity, and that while an influence is passing across from a body A to another body B, there is some dynamical process in action in the intervening region, though it appears to the senses to be mere empty space. The question is whether we can represent the facts more simply by supposing the intervening space to be occupied by a medium which transmits physical actions after the manner that a continuous material medium, solid or liquid, transmits mechanical disturbance. Various analogies of this sort are open to us: for example, the way in which a fluid medium transmits pressure from one immersed solid to another—or from one vortex ring belonging to the fluid to another, which is a much wider and more suggestive case; or the way in which an elastic fluid like the atmosphere transmits sound; or the way in which an elastic solid transmits waves of transverse as well as longitudinal displacement. It is on our familiarity with modes of transmission such as these, and with the exact analyses of them which the science of mathematical physics has been able to make, that our predilection for filling space with an æthereal transmitting medium, constituting a universal connexion between material bodies, largely depends; perhaps ultimately it depends most of all, like all our physical conceptions, on the intimate knowledge that we can ourselves exert mechanical effect on outside bodies only through the agencies of our limbs and sinews. The problem thus arises, Can we form a consistent notion of such a connecting medium? It must be a medium which can be effective for transmitting all the types of physical action known to us: it would be worse than no solution to have one medium to transmit gravitation, another to transmit electric effects, another to transmit light, and so on. Thus the attempt to find out a constitution for the æther will involve a synthesis or intimate correlation of the various types of physical agencies, which appear so different to us mainly because we perceive them through different senses. The evidence for this view, that all these agencies are at bottom connected together and parts of the same scheme, was enormously strengthened during the latter half of the 19th century by the development of a relation of simple quantitative equivalence between them; it has been found that we can define quantities relating to them, under the names of mechanical energy, electric energy, thermal energy, and so on, so that when one of them disappears it is replaced by the others to exactly equal amount. This single principle of energy has transformed physical science by making possible the construction of a network of ramifying connexions between its various departments: it thus stimulates the belief that these constitute a single whole, and encourages the search for the complete scheme of interconnexion of which the principle of energy and the links which it suggests form only a single feature.

Atomic Structure of Matter.—The greatest obstacle to such a search is the illimitable complexity of matter, as contrasted with the theoretical simplicity and uniformity of the physical agencies which connect together its different parts. It has been maintained since the times of the early Greek philosophers, and possibly even more remote ages, that matter is constituted of independent indestructible units, which cannot ever become divided by means of any mutual actions they can exert. Since the period, a century ago, when Dalton and his contemporaries constructed from this idea a scientific basis for chemistry, the progress of that subject has been wonderful beyond any conception that could previously have been entertained; and the atomic theory in some form appears now to be an indispensable part of the framework of physical science. Now this doctrine of material atoms is an almost necessary corollary to the doctrine of a universal æther. For if we held that matter is continuous, one of two alternatives would be open. We might consider that matter and æther can co-exist in the same space; this would involve the co-existence and interaction of a double set of properties, introducing great complication which would place any coherent scheme of physical action probably beyond the powers of human analysis. Or we might consider that æther exists only where matter is not, thus making it a very rare and subtle and elastic kind of matter; then we should have to assign these very properties to the matter itself where it replaces æther, in addition to its more familiar properties, and the complication would remain. The other course is to consider matter as formed of ultimate atoms, each the nucleus or core of an intrinsic modification impressed on the surrounding region of the æther; this might conceivably be of the nature of vortical motion of a liquid round a ring-core, thus giving a vortex atom, or of an intrinsic strain of some sort radiating from a core, which would give an electric atom. We recognize an atom only through its physical activities as manifested in its interactions with other atoms at a distance from it; this field of physical activity would be identical with the surrounding field of æthereal motion or strain that is associated with the atom, and is carried on along with it as it moves. Here then we have the basis of a view in which there are not two media to be considered, but one medium, homogeneous in essence and differentiated as regards its parts only by the presence of nuclei of intrinsic strain or motion—in which the physical activities of matter are identified with those arising from the atmospheres of modified æther which thus belong to its atoms. As regards laws of general physical interactions, the atom is fully represented by the constitution of this atmosphere, and its nucleus may be left out of our discussions; but in the problems of biology great tracts of invariable correlations have to be dealt with, which seem hopelessly more complex than any known or humanly possible physical scheme. To make room for these we have to remember that the atomic nucleus has remained entirely undefined and beyond our problem; so that what may occur, say when two molecules come into close relations, is outside physical science—not, however, altogether outside, for we know that when the vital *nexus* in any portion of matter is dissolved, the atoms will remain, in their number, and their atmospheres, and all inorganic relations, as they were before vitality supervened.

Nature of Properties of Material Bodies.—It thus appears that the doctrine of atomic material constitution and the doctrine of a universal æther stand to each other in a relation of mutual support; if the scheme of physical laws is to be as precise as observation and measurement appear to make it, both doctrines are required in our efforts towards synthesis. Our direct knowledge of matter can, however, never be more than a rough knowledge of the general average behaviour of its molecules; for the smallest material speck that is sensible to our coarse perceptions contains myriads of atoms. The properties of the most minute portion of matter which we can examine are thus of the nature of averages. We may gradually invent means of tracing more and more closely the average drifts of translation or orientation, or of changes of arrangement, of the atoms; but there will always remain an unaveraged residue devoid of any recognized regularity, which we can only estimate by its total amount. Thus, if we are treating of energy, we can separate out mechanical and electric and other constituents in it; and there will be a residue of which we know nothing except its quantity, and which we may call thermal. This merely thermal energy—which is gradually but very slowly being restricted in amount as new subsidiary organized types become recognised in it—though transmutable in equivalent quantities with the other kinds, yet is so only to a limited extent; the tracing out of the laws of this limitation belongs to the science of thermodynamics. It is the business of that science to find out what is the greatest amount of thermal energy that can possibly be recoverable into organized kinds under given circumstances. The discovery of definite laws in this region might at first sight seem hopeless; but the argument rests on an implied postulate of stability and continuity of constitution of material substances, so that after a cycle of transformations we expect to recover them again as they were originally—on the postulate, in fact, that we do not expect them to melt out of organized existence in our hands. The laws of thermodynamics, including the fundamental principle that a physical property, called temperature, can be defined, which tends towards uniformity, are thus relations between the properties of types of material bodies that can exist permanently in presence of each other; why they so maintain themselves remains unknown, but the fact gives a *point d'appui*. Returning now to the æther, on our present point of view no such complications there arise; it must be regarded as a continuous uniform medium free from any complexities of atomic aggregation, whose function is confined to the transmission of the various types of physical effect between the portions of matter. The problem of its constitution is thus one which can be attacked and continually approximated to, and which may possibly be definitely resolved. It has to be competent to transmit the transverse waves of light and electricity, and the other known radiant and electric actions; the way in which this is done is now in the main known, though there are still questions as to the mode of expression and formulation of our knowledge, and also as regards points of detail. This great advance, which is the result of the gradual focussing of a century's work in the minute exploration of the exact laws of optical and electric phenomena, clearly carries with it deeper insight into the physical nature of matter itself and its modes of inanimate interaction.

If we rest on the synthesis here described, the energy of the matter, even the thermal part, appears largely as potential energy of strain in the æther, which interacts with the kinetic energy associated with disturbances involving finite velocity of matter. It may, however, be maintained that an ultimate analysis would go deeper, and resolve all phenomena of elastic resilience into consequences of the kinetic stability of steady motional states, so that only motions, but not strains, would remain. On such a view the æther might conceivably be a perfect fluid, its fundamental property of elastic reaction arising (as suggested by Kelvin and FitzGerald) from a structure of tangled or interlaced vortex filaments pervading its substance, which might conceivably arrange themselves into a stable configuration and so resist deformation. This raises the further question as to whether the transmission of gravitation can be definitely recognized among the properties of an ultimate medium; if so, we know that it must be associated with some feature, perhaps very deep-seated, or on the other hand perhaps depending simply on incompressibility, which is not sensibly implicated in the electric and optical activities. With reference to all such further refinements of theory, it is to be borne in mind that the perfect fluid of hydrodynamic analysis is not a merely passive inert *plenum*; it is also a *continuum*, with the property that no finite internal slip or discontinuity of motion can ever arise in it through any kind of disturbance; and this property must be postulated, as it cannot be explained.

Motion of Material Atoms through the Æther.—An important question arises whether, when a material body is moved through the æther, the nucleus of each atom carries some of the surrounding æther along with it; or whether it practically only carries on its strain-form or physical atmosphere, which is transferred from one portion of æther to another after the manner of a shadow, or rather like a loose knot which can slip along a rope without the rope being required to go with it. We can obtain a pertinent illustration from the motion of a vortex ring in a fluid; if the circular core of the ring is thin compared with its diameter, and the vorticity is not very great, it is the vortical state of motion that travels across the fluid without transporting the latter bodily with it except to a slight extent very close to the core. We might thus imagine a structure formed of an aggregation of very thin vortex rings, which would move across the fluid without sensibly disturbing it; on the other hand, if formed of stronger vortices, it may transport the portion of the fluid that is within its own structure along with it as if it were a solid mass, and therefore also push aside the surrounding fluid as it passes. The motion of the well-known steady spherical vortex is an example of the latter case.

Convection of Optical Waves.—The nature of the motion, if any, that is produced in the surrounding regions of the æther by the translation of matter through it, can be investigated by optical experiment. The obvious body to take in the first instance is the Earth itself, which on account of its annual orbital motion is travelling through space at the rate of about 18 miles per second. If the surrounding æther is thereby disturbed, the waves of light arriving from the stars will partake of its movement; the ascertained phenomena of the astronomical aberration of light show that the rays travel to the observer, across this disturbed æther near the Earth, in straight lines. Again, we may split a narrow beam of light by partial reflection from a transparent plate, and recombine the constituent beams after they have traversed different circuits of nearly equivalent lengths, so as to obtain interference fringes. The position of these fringes will depend on the total retardation of the one beam with respect to the other; and thus it might be expected to vary with the direction of the Earth's motion relative to the apparatus. But it is found not to vary at all, even up to the second order of the ratio of the Earth's velocity to that of light. It has in fact been found, with the very great precision of which optical experiment is capable, that all terrestrial optical phenomena—reflection, refraction, polarization linear and circular, diffraction—are entirely unaffected by the direction of the Earth's motion; and this is our main experimental clue.

We pass on now to the theory. We shall make the natural supposition that motion of the æther, say with velocity (u,v,w) at the point (x,y,z), is simply superposed on the velocity V of the optical undulations through that medium, the latter not being intrinsically altered. Now the direction and phase of the light are those of the ray which reaches the eye; and by Fermat's principle, established by Huygens for undulatory motion, the path of a ray is that track along which the disturbance travels in least time, in the restricted sense that any alteration of any *short* reach of the path will increase the time. Thus the path of the ray when the æther is at rest is the curve which makes $\int ds/\mathrm{V}$ least; but when it is in motion it is the curve which makes $\int ds/(\mathrm{V} + lu + mv + nw)$ least, where (l, m, n) is the direction vector of δs. The latter integral becomes, on expanding in a series,

$$\int ds/\mathrm{V} - \int(udx + vdy + wdz)/\mathrm{V}^2 + \int(udx + vdy + wdz)^2/\mathrm{V}^3ds + \ldots,$$

since $lds = dx$. If the path is to be unaltered by the motion of the æther, as the law of astronomical aberration suggests, this must differ from $\int ds/\mathrm{V}$ by terms not depending on the path—that is, by terms involving only the beginning and end of it. In the case of the free æther V is constant; thus, if we neglect squares like $(u/\mathrm{V})^2$, the condition is that $udx + vdy + wdz$ be the exact differential of some function ϕ. If this relation is true along all paths, the velocity of the æther must be of irrotational type, like that of frictionless fluid. Moreover, this is precisely the condition for the absence of interference between the component of a split beam; because, the time of passage being to the first order

$$\int ds/\mathrm{V} - \int(udx + vdy + wdz)/\mathrm{V}^2,$$

the second term will then be independent of the path (ϕ being a single valued function) and therefore the same for the paths of both the interfering beams. If therefore the æther can be put into motion, we conclude that such motion, in free space, must be of strictly irrotational type.

But our experimental data are not confined to free space. If c is the velocity of radiation in free space and μ the refractive index of a transparent body, $\mathrm{V} = \mathrm{c}/\mu$; thus it is the expression $\mathrm{c}^{-2}\int\mu^2(u'dx + v'dy + w'dz)$ that is to be integrable exactly, where now (u',v',w') is what is added to V owing to the velocity (u,v,w) of the medium. As however our terrestrial optical apparatus is now all in motion along with the matter, we must deal with the rays relative to the moving system, and to them also Fermat's principle clearly applies; thus $\mathrm{V} + (lu' + mv' + nw')$ is here the velocity of radiation in the direction of the ray, but relative to the moving material system. Now the expression above given cannot be integrable exactly, under all circumstances and whatever be the axes of coordinates, unless $(\mu^2u',\mu^2v',\mu^2w')$ is the gradient of a continuous function. In the simplest case, that of uniform translation, these components of the gradient will each be constant throughout the region; at a distant place in free æther where there is no motion, they must thus be equal to $-u, -v, -w$, as they refer to axes moving with the matter. Hence the paths and times of passage of all rays relative to the material system will not be altered by a uniform motion of the system, provided the velocity of radiation relative to the system, in material of index μ, is diminished by μ^{-2} times the velocity of the system in the direction of the radiation, that is, provided the absolute velocity of radiation is increased by $1 - \mu^{-2}$ times the said velocity; this involves that the free æther for which μ is unity shall remain at rest. This statement constitutes the famous hypothesis of Fresnel, which thus ensures that all phenomena of ray-path and refraction, and all those depending on phase, shall be unaffected by uniform convection of the material medium, in accordance with the results of experiment.

Is the Æther Stationary or Mobile?—This theory secures that the times of passage of the rays shall be independent of the motion of the system, only up to the first order of the ratio of its velocity to that of radiation. But a classical experiment of Michelson, in which the ray-path was wholly in air, showed that the independence extends to higher orders. This result is inconsistent with the æther remaining at rest, unless we assume that the dimensions of the moving system depend, though to an extent so small as to be not otherwise detectable, on its orientation with regard to the æther that is streaming through it. It is however in complete accordance with a view that would make the æther near the Earth fully partake in its orbital motion—a view which the null effect of convection on all terrestrial optical and electrical phenomena also strongly suggests. But the æther at a great distance must in any case be at rest; while the facts of astronomical aberration require that the motion of that medium must be irrotational. These conditions cannot be consistent with sensible convection of the æther near the Earth without involving discontinuity in its motion at some intermediate distance: so that we are thrown back on the previous theory.

Another powerful reason for taking the æther to be stationary is afforded by the character of the equations of electrodynamics; they are all of linear type, and superposition of effects is possible. Now the kinetics of a medium in which the parts can have finite relative motions will lead to equations which are not linear—as, for example, those of hydrodynamics—and the phenomena will be far more complexly involved. It is true that the theory of vortex rings in hydrodynamics is of a simpler type; but electric currents cannot be likened to permanent vortex rings, because their circuits can be broken and the element of steadiness on which the simplicity depends thereby destroyed.

Dynamical Theories of the Æther.—The analytical equations which represent the propagation of light in free æther, and also in æther modified by the presence of matter, were originally developed on the analogy of the equations of propagation of elastic effects in solid media (See Wave Theory, *Ency. Brit.* vol. xxiv.). Various types of elastic solid medium have thus been invented to represent the æther, without complete success in any case. In MacCullagh's hands the correct equations were derived from a single energy formula by the principle of least action; and while the validity of this dynamical method was maintained, it was frankly admitted that no mechanical analogy was forthcoming. When Clerk Maxwell pointed out the way to the common origin of optical and electrical phenomena, these equations naturally came to repose on an electric basis, the connexion having been first definitely exhibited by FitzGerald in 1878; and according as the independent variable was one or other of the vectors which represent electric force, magnetic force, or electric polarity, they took the form appropriate to one or other of the elastic theories above mentioned.

In this place it must suffice to indicate the gist of the more recent developments of the electro-optical theory, which involve the dynamical verification of Fresnel's hypothesis regarding optical convection and the other relations above described. The æther is taken to be at rest; and the strain-forms belonging to the atoms are the electric fields of the intrinsic charges, or electrons, involved in their constitution. When the atoms are in motion these strain-forms produce straining and unstraining in the æther as they pass across it, which in its motional or kinetic aspect constitutes the resulting magnetic field; as the strains are slight the coefficient of inertia here involved must be great. True electric current arises solely from convection of the atomic charges or electrons; this current is therefore not restricted as to form in any way. But when the rate of change of æthereal strain—that is, of (f,g,h) specified as Maxwell's electric displacement in free æther—is added to it, an analytically convenient vector (u,v,w) is obtained which possesses the characteristic property of being circuital like the flow of an incompressible fluid, and has therefore been made fundamental in the theory by Maxwell under the name of the total electric current.

As already mentioned, all efforts to assimilate optical propagation to transmission of waves in an ordinary solid medium have failed; and though the idea of regions of intrinsic strain, as for example in unannealed glass, is familiar in physics, yet on account of the absence of mobility of the strain no attempt had been made to employ them to illustrate the electric fields of atomic charges. The idea of MacCullagh's æther, and its property of purely rotational elasticity which had been expounded objectively by Rankine, was therefore much vivified by Lord Kelvin's specification in 1889 of a material gyrostatically constituted medium which would possess this character. More recently a way has been pointed out in which a mobile permanent field of electric force could exist in such a medium so as to travel freely in company with its nucleus or intrinsic charge—the nature of the mobility of the latter, as well as its intimate constitution, remaining unknown.

A dielectric substance is electrically polarized by a field of electric force, the atomic poles being made up of the displaced positive and negative intrinsic charges in the atom: the polarization per unit volume (f',g',h') may be defined on the analogy of magnetism, and $d/dt(f',g',h')$ thus constitutes true electric current of polarization, *i.e.*, of electric separation in the molecules, specified per unit volume. The convection of a medium thus polarized involves electric disturbance, and therefore must contribute to the true electric current; the determination of this constituent of the current is the most delicate point in the investigation. The usual definition of the component current in any direction, as the net amount of electrons which crosses, towards the positive side, an element of surface *fixed in space* at right angles to that direction, per unit area per unit time, here gives no definite result. The establishment and convection of a single polar atom constitutes in fact a *quasi*-magnetization, the negative poles completing the current circuits of the positive ones. But in the transition from molecular theory to the electrodynamics of extended media, all magnetism has to be replaced by a distribution of current; the latter being now specified by volume as well as by flow, $(u,v,w)\delta\tau$ is the current in the element of volume $\delta\tau$. In the present case the total dielectric contribution to this current works out to be the change per unit time in the electric separation in the molecules of the element of volume, as it moves *uniformly* with the matter, all other effects being compensated molecularly without affecting the propagation.[1] On subtracting from this total the current of establishment of polarization $d/dt(f',g',h')$, already formulated above, there remains $vd/dx(f',g',h')$ as the current of convection of polarization when the convection is taken for simplicity to be in the direction of the axis of x with velocity v. The polarization itself is determined from the electric force (P,Q,R) by the usual statical formula

$$(f',g',h')=\frac{\mathrm{K}-1}{4\pi c^2}(\mathrm{P},\mathrm{Q},\mathrm{R}),$$

because any change of the dielectric constant K arising from the convection of the material through the æther must be independent of the sign of v and therefore be of the second order. Now the *electric force* (P,Q,R) is the force acting on the electrons of the medium moving with velocity v; consequently by Faraday's electrodynamic law

$$(\mathrm{P},\mathrm{Q},\mathrm{R})=(\mathrm{P}',\mathrm{Q}'-vc,\ \mathrm{R}'+vb)$$

where (P′,Q′,R′) is the force that would act on electrons at rest, and (a,b,c) is the magnetic induction. The latter force is, by Maxwell's hypothesis or by the dynamical theory of an æther pervaded by electrons, the same as that which strains the æther, and may be called the *æthereal force;* it thereby produces an æthereal electric displacement, say (f,g,h), according to the relation

$$(f,g,h)=(4\pi c^2)^{-1}(\mathrm{P}',\mathrm{Q}',\mathrm{R}'),$$

in which c is a constant belonging to the æther, which turns out to be the velocity of light. The current of æthereal displacement $d/dt(f,g,h)$ is what adds on to the true electric current to produce the total circuital current of Maxwell.

We have now to substitute these data in the universally valid circuital relations—namely, (i) line integral of magnetic force round a circuit is equal to 4π times the current through its aperture, which may be regarded as a definition of the constitution of the æther and its relation to the electrons involved in it; and (ii) line integral of the electric force belonging to any material circuit (*i.e.*, acting on the electrons situated on it which move with the velocity of the matter) is equal to *minus* the time-rate of change of the magnetic induction through that circuit as it moves with the matter, this being a dynamical consequence of the æthereal constitution assigned in (i).

We may now, as is somewhat the more natural course in the terrestrial application, take axes (x,y,z) which move with the matter; but the current must be invariably defined by the flux across surfaces fixed in space, so that we may say that relation (i) refers to a circuit fixed in space, while (ii) refers to one moving with the matter. These circuital relations, when expressed analytically, are then for a dielectric medium of types

$$\frac{d\gamma}{dy}-\frac{d\beta}{dz}=4\pi u,\ \ldots,\ \ldots,$$

where

$$(u,v,w)=\left(\frac{d}{dt}+v\frac{d}{dx}\right)(f',g',h')+\frac{d}{dt}(f,g,h),$$

and

$$\frac{d\mathrm{R}}{dy}-\frac{d\mathrm{Q}}{dz}=-\frac{da}{dt},\ \ldots,\ \ldots,$$

where, when magnetic quality is inoperative, the magnetic induction (a,b,c) is identical with the magnetic force (α,β,γ).

These equations determine all the phenomena. They take this simple form, however, only when the movement of the matter is one of translation. If v varies with respect to locality, or if there is a velocity of convection (p,q,r) variable with respect to direction and position, the analytical expression of the relation (ii) assumes a more complex form; we thus derive the most general equations of electrodynamic propagation for matter treated as continuous, anyhow distributed and moving in any manner.

---

[1] See Lorentz, *loc. cit. infra;* Larmor, *Æther and Matter*, p. 262 and *passim*.

For the simplest case of polarized waves travelling parallel to the axis of x, with the magnetic oscillation γ along z and the electric oscillation Q along y, all the quantities are functions of x and t alone; the total current is along y and given with respect to our moving axes by

$$v = \left(\frac{d}{dt} - v\frac{d}{dx}\right)\frac{Q + v\gamma}{4\pi c^2} + \frac{d}{dt}\left(\frac{K-1}{4\pi c^2}\right)Q;$$

also the circuital relations here reduce to

$$-\frac{d\gamma}{dx} = 4\pi v, \quad \frac{dQ}{dx} = -\frac{d\gamma}{dt};$$

thus

$$\frac{d^2Q}{dx^2} = 4\pi\frac{dv}{dt}$$

giving, on substitution for v,

$$(c^2 - v^2)\frac{d^2Q}{dx^2} = K\frac{d^2Q}{dt^2} - 2v\frac{d^2Q}{dxdt}.$$

For a simple wave-train, Q varies as sin $m(x - Vt)$, leading on substitution to the velocity of propagation V relative to the moving material, by means of the equation $KV^2 + 2vV = c^2 - v^2$; this gives, to the first order of v/c, $V = cK^{-\frac{1}{2}} - v/K$, which is in accordance with Fresnel's law. Trains of waves nearly but not quite homogeneous as regards wave-length will as usual be propagated as wave-groups travelling with the slightly different velocity $d(V\lambda^{-1})/d\lambda^{-1}$, the value of K occurring in V being a function of λ determined by the law of optical dispersion of the medium.

For purposes of theoretical discussions relating to moving radiators and reflectors, it is important to remember that the dynamics of all this theory of electrons involves the neglect of terms of the order $(v/c)^2$, not merely in the value of K but throughout.

The modification of the spectrum of a radiating gas by a magnetic field, such as would result from the hypothesis that the radiators are the system of revolving or oscillating electrons in the molecule, was detected by Zeeman in 1896; more minute investigation has largely confirmed the predictions as to its character that were made by H. A. Lorentz and others on the basis of the theoretical ideas here sketched.

Reference may be made generally to—MAXWELL. *Collected Papers.*—H. A. LORENTZ. *Archives Néerlandaises*, xxi. 1887, and xxv. 1892; and a tract, *Versuch einer Theorie der electrischen und optischen Erscheinungen in bewegten Körpern*, Leyden, 1895.—O. LODGE. "Aberration Problems," *Phil. Trans.* 1893 and 1897.—J. LARMOR, *Phil. Trans.* 1894-5-7, and a treatise *Æther and Matter*, Cambridge Univ. Press, 1900, where full references are given. See also in *Ency. Brit.* (9th ed.) articles ATOM, ETHER, MOLECULE, ELECTRICITY, WAVE THEORY.

(J. L.*)

Afforestation. See FORESTS.

Affreightment.—*Contract of Affreightment* is the expression usually employed to describe the contract between a shipowner and some other person called the freighter, by which the shipowner agrees to carry goods of the freighter in his ship, or to give to the freighter the use of the whole or part of the cargo-carrying space of the ship for the carriage of his goods on a specified voyage or voyages, or for a specified time; the freighter on his part agreeing to pay a specified price, called "freight," for the carriage of the goods or the use of the ship. A ship may be let like a house to some person who takes possession and control of it for a specified term. The person who hires a ship in this way occupies during the currency of his term the position of shipowner. The contract by which a ship is so let may be called a *charter-party*; but it is not, properly speaking, a contract of affreightment, and is mentioned here only because it is necessary to remember the distinction between a *charter-party* of this kind, which is sometimes called a demise of the ship, and a *charter-party* which is a form of contract of affreightment, as will hereinafter appear.

The law with regard to the contract of affreightment is, of course, a branch of the general law of contract. The rights and obligations of the shipowner and the freighter depend, as in the case of all parties to contracts, upon the terms of the agreement entered into between them. The law, however, interferes to some extent in regulating the effect to be given to contracts. Certain contracts are forbidden by the law, and being illegal are, therefore, incapable of enforcement. The most important example of illegality in the case of contracts of affreightment is when the contract involves trading with an enemy. The law interferes again with regard to the interpretation of the contract. The meaning to be given to the words of the contract, or, in other words, its construction, when a dispute arises about it, must be determined by the judge or court. The result is, that certain more or less common clauses in contracts of affreightment have come before the courts for construction, and the decisions in these cases are treated practically, though not perhaps quite logically, as rules of law determining the sense to be put upon certain forms of expression in common use in shipping contracts. A third way in which the law interferes is by laying down certain rules by which the rights of the parties are to be regulated in the absence of any express stipulation with regard to the matter dealt with by such rules. This is done either by statutory enactment, as by that part (Part VIII.) of the Merchant Shipping Act, 1894, which deals with the liability of shipowners; or by established rules of the unwritten law, the "common law" as it is called, as, for instance, the rule that the common carrier is absolutely responsible for the safe delivery of the goods carried, unless it is prevented by the act of God or the King's enemies. These rules of law, whether common law or statute law, regulating the obligations of carriers of goods by sea, are of most importance in cases which are uncommon though not unknown at the present day, in which there is an affreightment without any written agreement of any kind. It will, therefore, be convenient to consider first cases of this kind where there is no express agreement, oral or written, except as to the freight and destination of the goods, and where consequently the rights and obligations of the parties as to all other terms of carriage depend wholly upon the rules of law, remembering always that these same rules apply when there is a written contract, except in so far as they are qualified or negatived by the terms of such contract.

Rules of law.

The rules of the common or ancient customary law of England with regard to the carriage of goods were no doubt first considered by the courts and established with regard to the carriage of goods by common carriers on land. These rules were applied to common carriers by water, and it may now be taken to be the general rule that shipowners who carry goods by sea are by the English law subject to the liabilities of common carriers. (See as to the grounds and precise extent of this doctrine the judgments in *Liver Alkali Company* v. *Johnson*, L.R., 7 Ex. 267, and *Nugent* v. *Smith*, 1 C.P.D. 423.) In practice goods are not often shipped without a written contract or acknowledgment of the terms upon which they are to be carried. For each separate consignment or parcel of goods shipped a *bill of lading* is almost invariably given, and when a whole cargo is agreed to be carried the terms are set out in a document called a *charter-party*, signed by or on behalf of the shipowner on the one part, and the shipper, who is called the *charterer*, on the other part. But at present we are considering the relations of shipowner and shipper independently of any express contract, as in a case when goods are shipped and received to be carried to the place to which the ship is bound for a certain freight, but without any further agreement as to the terms of carriage. In such a case the rights of the parties depend on the rules of law, or, which is much the same thing, upon the warranties or promises which though not expressed must, as the courts have held, be implied as arising from the relation between the parties as shipper and carrier. The obligations on the one side and the other may be defined shortly to be as follows:— The shipper must not ship goods of a nature or in a condition which he knows, or ought, if he used reasonable care, to know to be dangerous to the ship, or to other goods, unless the shipowner has notice of or has sufficient opportunity to observe their dangerous character. The shipper must be prepared, without notice from the shipowner, to take delivery of his goods with reasonable despatch on the arrival of the ship at the place of destination, being ready there to discharge in some usual discharging place. The shipper must pay the agreed freight, and will not be entitled to claim delivery until the freight has been paid. In other words, the shipowner has a *lien* on the goods carried for the freight payable in respect of the carriage. On the other hand the obligation upon the shipowner is first and foremost to deliver safely at their destination the goods shipped, and this obligation is, by the common law, subject to this exception only that the shipowner is not liable for loss or damage caused by the act of God or the King's enemies; but by statute (Merchant Shipping Act, 1894, Part VIII.) it is further qualified to this extent that the shipowner is not liable for loss, happening without his actual fault or privity, by fire on board the ship, or by the robbery, or embezzlement of, or making away with gold, or silver, or jewellery, the true nature and value of which have not been declared in writing at the time of shipment; and, further, the shipowner is not liable for damage to or loss of goods or merchandise beyond an aggregate amount, not exceeding eight pounds per ton for each ton of the ship's tonnage. The shipowner is bound by an implied undertaking, or, in other words, is made responsible by the law as if he had entered into an express undertaking: (1) that the ship is seaworthy; (2) that she shall proceed upon the voyage with reasonable despatch, and shall not deviate without necessity from the usual course of the voyage.

In default of express contract.

It is not our purpose in this article to discuss minute or doubtful questions; but in their general outline the obligations of shipper and shipowner, where no terms of carriage have been agreed, except as to the freight and destination of the goods, are such as have been described above. The importance of appreciating clearly this view of the relations of shipper and shipowner arises from the fact that these fundamental rules apply to all contracts of affreightment, whether by bill of lading, charter-party, or otherwise, except in so far as they are modified or negatived by the express terms of the contract.

Bills of Lading.

The document signed by the master or agent for the shipowner, by which are acknowledged the shipment of a parcel of goods and the terms upon which it is to be carried, is called a Bill of Lading. Very many different forms of bills of lading are used. For the purpose of illustration the following form (from Mr Scrutton's book on *Charter-parties and Bills of Lading*) has been selected as a sample:—

> Shipped, in apparent good order and condition by in and upon the good Vessel called the now lying in the port of and bound for , with liberty to call at any ports in any order, to sail without Pilots, and to tow and assist Vessels in distress, and to deviate for the purpose of saving life or property; and to be delivered in the like good order and condition at the aforesaid port of unto or to his or their assigns, freight and all other conditions as per Charter Party. The act of God, perils of the sea, fire, barratry of the Master and Crew, enemies, pirates, and thieves, arrests, and restraints of princes, rulers, and people, collisions, stranding, and other accidents of navigation excepted, even when occasioned by negligence, default, or error in judgment of the Pilot, Master, Mariners, or other servants of the Shipowners.
>
> Ship not answerable for losses through explosion, bursting of boilers, breakage of shafts, or any latent defect in the machinery or hull, not resulting from want of due diligence by the Owners of the Ship, or any of them, or by the Ship's Husband or Manager.
>
> General Average payable according to York-Antwerp Rules.
>
> In Witness whereof, the Master or Agent of the said Ship hath affirmed to three Bills of Lading, all of this tenor and date, drawn as first, second and third, one of which Bills being accomplished, the others to stand void.
>
> Dated in this day of 188 .

The Bill of Lading is an acknowledgment of the shipment of goods in a named vessel for carriage to a specified destination on terms set forth in the document. It is usually signed by the master of the vessel, but very commonly by the agents of the shipowner or sometimes of the charterers of the vessel. A vessel may be employed by its owners to earn freight in various ways: (1) It may be placed, as it is said, on the berth as a general ship, to receive cargo from any shippers who may desire to send goods to the port, or one of the ports, to which the vessel is bound. The mate or chief officer usually superintends the loading, and, as goods are shipped, *a mate's receipt* is given as an acknowledgment of the shipment. The *mate's receipt* is afterwards exchanged for the *bill of lading*. In the case of a shipment by a general ship the bill of lading is the evidence and memorandum of the contract between the shipowner and the shipper; (2) a shipper may, however, require the whole cargo space of the vessel to carry, for example, a full cargo of grain. In such a case the vessel will be chartered by the shipowner to the shipper, and the contract will be the charter-party. Even in such a case a bill or bills of lading will usually be given to enable the shipper to deal more conveniently with the goods by way of sale or otherwise. By the ancient custom of merchants recognized and incorporated in the law, the bill of lading is a document of title, representing the goods themselves, by the transfer of which symbolical delivery of the goods may be made. But when a cargo is shipped under a charter-party, although bills of lading may be given to the charterer, it is the charter-party, and not the bills of lading, which constitutes the record of the contract between the parties—of *charter-parties* we shall treat below. (3) There is a third class of case which is a combination of the two with which we have dealt above. A vessel is very commonly chartered by her owner to a charterer who has no intention to ship and does not ship any cargo on his own account, but places the vessel on the berth to receive cargo from shippers who ship under bills of lading. The charterer receives the bill of lading freight and pays the charter-party freight, his object being of course to obtain a total bill of lading freight in excess of the chartered freight, and so make a profit. The master, although he usually remains the servant of the shipowner during the term of the charter-party, acts nevertheless under the directions and on behalf of the charterer in signing bills of lading. The legal effect of this situation is that shippers who ship goods under bills of lading without knowledge of the terms of the charter-party are entitled to look to the shipowner as the person responsible to them for the safe carriage of their goods. This right depends essentially on the fact that the master who signs the bills of lading, although in doing so he is acting for the charterer, remains nevertheless the servant of the shipowner, who is not allowed to deny as against third persons, who do not know the relations between the charterer and the shipowner, that his servant, the master of the ship, has the ordinary authority of a master to bind his owner by signing bills of lading.

The forms of bills of lading vary very much, and their clauses have been the subject of judicial consideration and decision in a vast number of reported cases. The essential particulars, or at all events those common to all bills of lading, may be stated as follows:

1. The name of the shipper.
2. The name of the ship.
3. The place of loading and destination of the ship.
4. A description of the goods shipped.
5. The place of delivery.
6. The persons to whom delivery is to be made.
7. The freight to be paid.
8. The excepted perils.
9. The shipowner's lien.

The description of (1) the shipper, and (2) the ship, calls for no remark. The (3) description of the voyage is important, because there is, as we have already explained, an implied undertaking by the shipowner in every contract of carriage not unnecessarily to deviate from the ordinary route of the voyage upon which the goods are received to be carried. The consequences of a deviation are serious, inasmuch as the shipowner is liable, not only for any loss or damage which the shipper suffers in consequence of the deviation, but for any loss of goods which occurs after the deviation, even though such loss is caused by one of the excepted perils. The only exception to this rule is that a deviation may be made to save life, but not to save property. It is, however, very usual to qualify the strictness of this implied undertaking by introducing in the bill of lading certain "liberties" to deviate, as, for example, in the form given above, "liberty to call at any ports in any order, to tow and assist vessels in distress, and to deviate for the purpose of saving life and property." The nature and extent of the liberty will depend on the words of the contract. The inclination of English courts has been to construe clauses giving a liberty to deviate somewhat strictly against the shipowner.

The (4) importance of the description of the goods shipped and their condition is obvious, as the contract is to deliver them as described and in the like good condition, subject, of course, to the exceptions. It must, however, be noted, that, as against the master or person who has himself signed the bill of lading, the description therein of the goods shipped is absolutely conclusive. But as against the shipowner, unless he has himself signed the bill of lading, the description of the goods shipped is not conclusive. It is evidence as against him that the goods described were shipped, but he is allowed to rebut this evidence by proving, if he can, that the goods mentioned, or some of them, were not in fact shipped.

As to (5) the place of delivery, very serious questions frequently arise. Primarily, of course, the shipowner is bound to deliver at the place named. Should he be prevented by some obstacle or difficulty which is of a temporary nature, the vessel must wait, and delivery must be made as soon as possible. Where, however, the obstacle is permanent, or at all events such as must cause unreasonable delay, having regard to the nature of the adventure, the shipowner is excused from delivery at the place named in the bill of lading, provided the difficulty arises from an excepted peril, or in consequence of delivery at the place named being forbidden by the law of England, as may happen, for example, in the case of a declaration of war between Great Britain and the state in which the port named in the bill of lading is situate. A party to a contract cannot be held liable for breaking his contract if its performance has become illegal. There may be other cases in which, from the circumstances of the voyage and adventure, it must be inferred that the parties intended the performance of the contract to be conditional on the existence at the time of performance of a certain state of things, the non-existence of which would render performance impossible. For instance, if the port named in the bill of lading became permanently closed and inaccessible to shipping in consequence of an earthquake, it would probably be held that the continued existence of the place named as a port was an implied condition of the contract, and that the shipowner was excused. Where, however, the performance of the contract remains lawful, and is not excused by the express terms of the contract, or by some implied condition, the shipowner is liable for any loss or damage suffered by the shipper by reason of his goods not being delivered at the named place, even though such delivery has become impossible. There is another reason why the precise description of the place of delivery often becomes important. It is only on the arrival of the ship at the place described as the place of delivery that the obligation of the consignee of the goods to take delivery commences. Delay involves considerable loss and expense to the shipowner. The shipper or consignee is not responsible for any delay which occurs before the ship has arrived at the place of delivery described in the bill of lading.

(6) The goods may be deliverable by the terms of the bill of lading to a named consignee, and to him only, but more usually they are made deliverable to the "order or assigns" of the named consignee or of the shipper. If the goods are made deliverable to order or assigns the bill of lading is a negotiable instrument, or, in other words, the right to the goods, and the rights and liabilities under the contract contained in the bill of lading, may be transferred by indorsement and delivery of the document. When an indorsement has once been made by the shipper or consignee writing his name and nothing more on the back of the bill of lading, the rights in and under it may be transferred from hand to hand by mere delivery. A bill of lading so indorsed is said to be indorsed "in blank." But the shipper or consignee may restrict the negotiability of the bill of lading by indorsing it not "in blank," but with a direction requiring delivery to be made to a particular person or indorsee, or to his order. This is called an indorsement "in full." When an indorsement has been made "in full" to a named indorsee or order, such indorsee must again indorse "in blank" or "in full" to effect a new transfer of the rights in the bill of lading.

(7) The amount or rate of *freight* payable is stated in the bill of lading, either expressly, or, not uncommonly when the freight under the bill of lading is the same as under the charter-party, by reference to the charter-party. A common form of such reference is "freight and other conditions, as per charter-party." It may here be mentioned that this form of words does not incorporate in the contract under the bill of lading all the terms and conditions of the charter-party, but only those which apply to the person who is to take delivery, and relate to matters *ejusdem generis*, or similar to the payment of freight, such as demurrage and the like. The conditions of the charter-party thus incorporated do not include, for instance, the exceptions in the charter-party so as to add them to the

exceptions in the bill of lading. Freight, unless it is otherwise provided by the contract, is payable only on delivery of the goods at their destination. If the voyage is interrupted and its completion becomes impossible, the shipowner cannot claim payment of freight even *pro ratâ itineris*. He loses his freight altogether. This is so even when the completion of the voyage is prevented by causes for which the shipowner is not responsible, such as the act of God or the King's enemies, or perils which are within the express exceptions in the bill of lading. When the voyage is interrupted by accident, and indeed in any case, the goods may, by agreement between the shipowner and the consignee, be delivered at some place short of their destination upon payment of a freight *pro ratâ*; that is to say, proportional to the length of voyage accomplished, and such an agreement may be implied in certain circumstances from the conduct of the consignee in taking delivery before they arrive at their destination. In all such cases it will be a question of fact whether the goods were in fact delivered upon the terms, express or implied, that freight *pro ratâ* should be paid. As a rule such an agreement would not be implied where the shipowner is unable or unwilling to forward the goods to their destination, and the owner of the goods, therefore, has no option but to take delivery of them there.

When the ship is disabled and cannot proceed, or she is prevented by some obstacle from proceeding to the place of delivery named in the bill of lading, and the shipowner is unwilling or unable to forward the goods by another ship, even though he may be excused for his failure to carry the goods to their destination, he is not entitled to be paid any part of the freight; and the consignee is entitled to have the goods delivered to him either at the place where the vessel has taken refuge in her disabled condition, or, if the obstacle arises without disablement of the vessel, at the place which is nearest and most reasonably convenient at the time and in the circumstances when the further prosecution of the voyage has to be abandoned. On the other hand, after the goods have been shipped, so long as the shipowner is ready and willing to carry the goods to their destination, or, if the ship is disabled, to forward them to their destination by some other ship without unreasonable delay, the owner of the goods cannot require the goods to be delivered to him at any place short of their destination without payment of the full freight. Sometimes the freight, either wholly or in part, is made payable *in advance*. If freight payable in advance has become due, even though the ship is lost before it is paid, it must, in the absence of some special provision to the contrary, still be paid, and freight already paid in advance does not become repayable because the goods do not reach their destination. If, however, goods upon which freight has been paid in advance are lost, and the shipowner is liable for their loss, the amount of freight paid in advance must be taken into account in assessing the damage recoverable from the shipowner.

(8) There is no part of the bill of lading which is of greater practical importance or which demands more careful consideration by shipowner and shipper alike than that which sets forth the excepted perils; those perils, in other words, or causes of loss for which the shipowner is to be exempt from liability. By the common law, as we have seen, the exemption of the carrier, apart from express contract, extended only to loss by the act of God or the King's enemies. The expression "act of God" requires a word of explanation. It will be sufficient to say that it is not synonymous with *force majeure*; but it includes every loss by *force majeure* in which human agency, by act or negligence, has had no part. The list of excepted perils varies much in different forms of bills of lading. In the older forms it usually included perils of the seas, robbers and pirates, restraint of princes and rulers, fire and barratry (that is, wilful wrongdoing) of the master and crew. The list, however, has grown in modern times, and is still growing; the tendency being to exempt the shipowner from liability for all loss which does not arise from his own personal default, or from the negligence of his managers or agents in failing to provide a vessel seaworthy and fit for the voyage at its commencement. It is important to point out in this connexion that there are two duties which the shipowner is always presumed to undertake, and which are assumed to be unaffected and unqualified by the exceptions, unless a contrary intention is very clearly expressed by the terms of the contract. In the first place, he undertakes absolutely that the ship in which the goods are shipped is fit at the commencement of the voyage for the service to be performed. If during the voyage loss arises even from dangers of the seas or other excepted peril which would not have occurred if the vessel had been seaworthy and fit for the voyage at its commencement, the shipowner is not protected by the exceptions, and is liable for the loss. In the second place, there is an implied undertaking by the shipowner that all reasonable care will be taken by himself, his servants, and agents, safely to carry and deliver at their destination the goods received by him for carriage. Should loss or damage occur during the voyage, though the direct cause of such loss or damage be perils of the seas or other excepted peril, still the shipowner cannot claim exemption under the exceptions, if the shipper can prove that the loss or damage would not have occurred but for the negligence of the master, or crew, or other servants of the shipowner. The shipowner, in other words, is bound by himself and his servants to use all reasonable care to prevent loss by excepted perils as well as by any other cause.

Express stipulations.

It must not be supposed that even these primary obligations, which are introduced into every contract of affreightment not by words but by implication, may not be excluded by the express terms of the contract. It has now become common form to stipulate that the shipowner shall not be liable for any loss arising from the negligence of his servants, or that he shall not be liable for loss by the excepted perils even when brought about by the negligence of his servants. And with regard to seaworthiness, it is not uncommon for the shipowner to stipulate that he shall not be responsible for loss arising even from the unseaworthiness of the ship on sailing, provided that due care has been taken by the owner, and his agents, and servants to make the ship seaworthy at the commencement of the voyage. There is indeed no rule of English law which prevents a shipowner from exempting himself by the terms of the bill of lading from liability for damage and loss of every kind, whether arising from unseaworthiness or any other cause whatsoever. In such a case the goods are carried at the owner's risk, and if he desires protection he must obtain it by insurance. In this respect the law of England permits greater freedom of contract than is allowed by the law of some other states. The owners, agents, and masters of vessels loading in the United States of America are forbidden by an Act of Congress, commonly called the Harter Act, passed in the year 1893, to insert in their contracts of affreightment any clause exempting the shipowner from liability for the negligence of his servants; but it is at the same time enacted that, provided all reasonable skill and care has been exercised by the shipowner to make the vessel seaworthy and fit for the voyage at its commencement, the shipowner shall not be liable for any loss caused by the negligence of the master or crew in the navigation of the vessel, or by perils of the sea or certain other causes set forth in the Act. It is now very usual to insert in the bills of lading of British vessels loading in the United States a reference to the Harter Act, incorporating its provisions so as to make them terms and conditions of the bill of lading.

The difficulty of construing the terms of bills of lading with regard to the excepted perils, often expressed in obscure and inexact language, has given rise to much litigation, the results of which are recorded in the Law Reports. Where such difficulties arise the question must be, What is the true and natural meaning of the language used by the parties? This question is not governed by the general rules which we have endeavoured to explain; but the words of the contract must always be considered with reference to these rules, which are founded upon the well-established customs of merchants recognized and formulated by the courts of law.

(9) The bill of lading sometimes contains a clause as to the shipowner's *lien*. Without any express provision for it the shipowner has by the common law a lien for freight. If it is desired to give the shipowner a lien for *demurrage* (see below), or other charges, it must be expressly provided for. The *lien* is the right of the shipowner to retain the goods carried until payment has been made of the freight or the demurrage, or other charge for which a lien has been given. The lien may be waived, and is lost by delivery of the goods, or by any dealing with the consignee which is inconsistent with a right of the shipowner to retain possession of the goods until payment has been made. The shipowner may preserve his lien by landing the goods and retaining them in his own warehouse, or by storing them in a public warehouse, subject to the conditions required by the Merchant Shipping Act, 1894.

Charter-parties.

Charter-parties are, as we have already explained, either for a voyage or for a period of time. (1) A charter-party for a voyage is a formal agreement made between the owner of the vessel and the charterers by which it is agreed that the vessel "being tight, staunch, and strong, and every way fitted for the voyage," shall load at a certain named place a full cargo either of goods of a specified description or of general merchandise, and being so loaded shall proceed with all possible despatch either to a specified place or to a place to be named at a specified port of call, and there deliver the cargo to the charterers or their assigns. There are clauses which provide for the amount of freight to be paid and the manner and time of payment; for the time, usually described as *lay days*, to be allowed for loading and discharging, and for the *demurrage* to be paid if the vessel is detained beyond the lay days; usually also a clause requiring "the cargo to be brought to and taken from alongside at merchant's risk and expense"; a clause that the master shall sign bills of lading for the cargo shipped either at the same rate of freight as is payable under the charter-party or very commonly at any rate of freight (but in this case with a stipulation that, if the total bill of lading freight is less than the total freight payable under the charter-party, the difference is to be paid by the charterers to the master before the sailing of the vessel); and there is usually what is called the *cesser clause*, by which the charterer's liability under the charter-party is to cease on shipment of the cargo, the shipowner taking a lien on the cargo for freight, dead freight, and demurrage. The charter-party is made subject to exceptions similar to those which are found in bills of lading. There are also usually clauses providing for the commissions to be paid to the brokers on signing the charter-party, the "address" commission to be paid to the agents for the vessel at the port of discharge, and other matters of detail. The clauses in charter-parties vary of course indefinitely, but the above is probably a sufficient outline of the ordinary form of a charter-party for a voyage.

What has been said with regard to bills of lading as to the voyage, the place of delivery, the exceptions and excepted perils, and the liability of the shipowner and his lien applies equally to charter-parties. It may be desirable to add a few words on *demurrage*, *dead freight*, and on the *cesser clause*.

Demurrage is, properly speaking, a fixed sum per day or per hour agreed to be paid by the charterer for any time during which the vessel is detained in loading or discharging over and above the time allowed, which is, as we have said, usually described as the *lay days*. Sometimes the number of days during which the vessel may be kept on demurrage at the agreed rate is fixed by the charter-party. If no demurrage is provided for by the charter-party, and the vessel is kept loading or discharging beyond the lay days, the shipowner is entitled to claim damages in respect of the loss which he has suffered by the detention of his ship; or, if the vessel is detained beyond the fixed number of demurrage days, damages for detention will be recoverable. Sometimes there is no time fixed by the charter-party for loading or discharging. The obligation in such cases is to load or discharge with all despatch that is possible and reasonable in the circumstances; and if the loading or discharging is not done with such reasonable despatch, the shipowner will be entitled to claim damages for the detention of his ship. The rate of demurrage (if any) will generally be accepted as the measure of the damages for detention, but is not necessarily the true measure. When the claim is for detention and not demurrage the actual loss is recoverable, which may be more or may be less than the agreed rate of demurrage. The contract usually provides that Sundays and holidays shall be excepted in counting the lay days, but unless expressly stipulated this exception does not apply to the computation of the period of detention after the lay days have expired.

Dead freight is the name given to the amount of freight lost, and therefore recoverable by the shipowner from the charterer as damages if a full and complete cargo is not loaded in accordance with the terms of the charter-party.

The *cesser clause* has come into common use because very frequently the charterers are not personally interested in the cargo shipped. They may be agents merely, or they may have chartered the vessel as a speculation to make a profit upon the bill of lading freight. The effect of the clause is that when the charterers have shipped a full cargo they have fulfilled all their obligations, the shipowner discharging them from all further liability and taking instead a lien on the cargo for payment of all freight, demurrage, or dead freight that may be payable to him. It has become an established rule for the construction of the *cesser clause* that, if the language used will permit it, the cesser of liability is assumed to be coextensive only with the lien given to the shipowner; or, in other words, the charterers are released from those liabilities only for which a lien is given to the shipowner. The shipowner is further secured by the stipulation already referred to, that if the total freight payable under the bills of lading is less than the full chartered freight the difference shall be paid to the shipowner before the vessel sails. A difficulty which sometimes arises, notwithstanding these precautions, is that although an ample lien is given by the charter-party the terms of the bills of lading may be insufficient to preserve the same extensive lien as against the holder of the bills of lading. The shippers under the bills of lading, if they are not the charterers, are not liable for the chartered freight, but only for the bill of lading freight; and unless the bill of lading expressly reserves it, they are not subject to a lien for the chartered freight. The master may guard against this difficulty by refusing to sign bills of lading which do not preserve the shipowner's lien for his full chartered freight. But he is often put into a difficulty by a somewhat improvident clause in the charter-party requiring him to sign bills of lading *as presented*.

(2) A time charter-party is a contract between the shipowner and charterers, by which the shipowner agrees to let and the charterers to hire the vessel for a specified term for employment, either generally in any lawful trade or upon voyages within certain limits. A place is usually named at which the vessel is to be redelivered to the owners at the end of the term, and the freight is payable until such redelivery; the owner almost always pays the wages of the master and crew, and the charterers provide coals and pay port charges; the freight is usually fixed at a certain rate per gross register ton per month, and made payable monthly in advance, and provision is made for suspension of hire in certain cases if the vessel is disabled; the master, though he usually is and remains the servant of the owner, is required to obey the orders of the charterers as regards the employment of the vessel, they agreeing to indemnify the owners from all liability to which they may be exposed by the master signing bills of lading or otherwise complying with the orders of the charterers; and the contract is made subject to exceptions similar to those in bills of lading and voyage charter-parties. This is the general outline of the ordinary form of a time charter-party, but the forms and their clauses vary of course very much, according to the circumstances of each case.

It is apparent that under a time charter-party the shipowner to a large extent parts with the control of his ship, which is employed within certain limits according to the wish and directions, and for the purposes and profit of, the charterers. But, as we have already explained at the beginning of this article, the shipowner continues in possession of his vessel by his servant the master, who remains responsible to his owner for the safety and proper navigation of the ship. The result of this, as has been already pointed out, is that the holder of a bill of lading signed by the master, if he has taken the bill of lading without knowledge of the terms of the time charter-party, may hold the owner responsible for the due performance of the contract signed by the master in the ordinary course of his duties, and within his ostensible authority as servant of the shipowner, although in fact in signing the bill of lading the master was acting as agent for and at the direction of the time charterer, and not the shipowner. In the language of the ordinary time charter-party the ship is *let* to the charterers; but there is no true demise, because, as we have pointed out, the vessel remains in the possession of the shipowner, the charterer enjoying the advantages and control of its employment. Where the possession of a ship is given up to a hirer, who appoints his own master and crew, different considerations apply; but though the instrument by which the ship is let may be called a charter-party, it is not truly a contract of affreightment.

Customary rights.

There are certain rights and obligations arising out of the relationship of shipowner and cargo-owner in circumstances of extraordinary peril or urgency in the course of a voyage, which, though not strictly contractual, are well established by the custom of merchants and recognized by the law. It is obvious that, when a ship carrying a cargo is in the course of a voyage, the master to some extent represents the owners of both ship and cargo. In cases of emergency it may be necessary that the master should, without waiting for authority or instructions, incur expense or make sacrifices as agent not only of his employer, the shipowner, but also of the cargo-owner. Ship and cargo may be in peril, and it may be necessary for the safety of both to put into a port of refuge. There it may be necessary to repair the ship, and to land and warehouse, and afterwards reship the cargo. For these purposes the master will be obliged to incur expense, of which some part, such as the cost of repairing the ship, will be for the benefit of the shipowner; part, such as the warehousing expenses, will be for the benefit of the cargo-owner; and part, such as the port charges incurred in order to enter the port of refuge, are for the common benefit and safety of ship and cargo. Again, in a storm at sea, it may be necessary for the safety of ship and cargo to cut away a mast or to jettison, that is to say, throw overboard part of the cargo. In such a case the master, acting for the shipowner or cargo-owner, as the case may be, makes a sacrifice of part of the ship or part of the cargo, in either case for the purpose of saving ship and cargo from a danger common to both. Voluntary sacrifices so made and extraordinary expenses incurred for the common safety are called GENERAL AVERAGE (*q.v.*) sacrifices and expenses, and are made good to the person who has made the sacrifice or incurred the expense by a general average contribution, which is recoverable from the owners of the property saved in proportion to its value, or, in other words, each contributes ratably according to the benefit received. The law regulating the rights of the parties with regard to such contribution is called the Law of General Average. It must, however, be remembered that the owner of the cargo is entitled under the contract of affreightment to the ordinary service of the ship and crew for the safe carriage of the cargo to its destination, and the shipowner is bound to pay all ordinary expenses incurred for the purpose of the voyage. He must also bear all losses arising from damage to the ship by accidents. But when extraordinary expense has been incurred by the shipowner for the safety of the cargo, he can recover such expense from the owner of the cargo as a *special charge* on cargo; or when an extraordinary expense has been incurred or a voluntary sacrifice made by the shipowner to save the ship and cargo from a peril common to both, he may require the owner of cargo to contribute in *general average* to make good the loss.

See CARVER, *Carriage by Sea.* London, 1899.—SCRUTTON, *Charter-parties and Bills of Lading.* London, 1900. (W.)

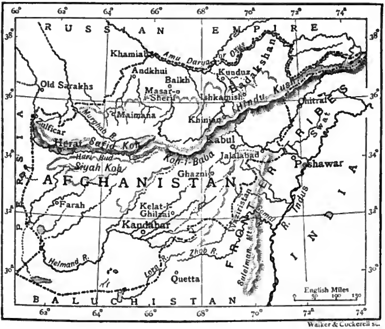
AFGHANISTAN.

GEOGRAPHY AND STATISTICS.

VERY much was contributed to our knowledge of Afghanistan during the last quarter of the 19th century. The Afghan war of 1878-80 afforded an opportunity for the extension of wide geographical surveys on a scientific basis; and this opportunity was afterwards repeated by the Russo-Afghan Boundary Commission of 1884-86. Since then much of the country on the immediate borders of India has been explored by the native employés of the Indian Survey during the progress of a series of minor expeditions: and the boundary delimitations which resulted from the agreement of November 1893 at Kabul, together with the frontier campaign of 1897-98, have finally reduced the geography of the whole borderland to practical shape. For the purposes of this article there will be included within the general term "Afghanistan" not only those districts which fall within the new political boundaries of the Kabul Government, but those states on the border, lying between Afghanistan and British India, whose status has lately been defined as "independent," and which are peopled either by Pathans or Afghans, speaking the same language and belonging to the same religious community as the Afghans of the Kabul kingdom.

River Basins.—Whilst, broadly speaking, the chief features of Afghan topography and hydrography were well enough known previously to the Afghan war of 1878, certain modifications in detail are to be noted in modern maps, and much supplementary information can now be added. It will be convenient to deal with Afghanistan under the natural divisions of its river basins rather than of the separate provinces included within its political boundaries. The following are the chief hydrographic divisions of the country—(1) the Kabul river and its tributaries; (2) the Indus affluents, which for the most part drain the independent provinces of the frontier; (3) the Oxus basin; (4) the basin of the Helmand; (5) the basin of the Hari Rud.

The Kabul river rises at the foot of the Unai pass, leading over the Sanglakh range, an offshoot of the Hindu Kush, towards Bamian and Afghan Turkestan. From its source to Kabul is only 45 miles as the crow flies, and the amount of water which the river carries is small and often insufficient for purposes of irrigation. Neither in volume nor in length is it to be compared with the Logar river, which joins it at a point less than half a mile east of Kabul. The Logar rises beyond Ghazni, amongst the slopes of the Gul Koh (14,200 feet), which overlooks the Ghazni plain from the west, and with minor affluents drains the rich valleys of Logar and Wardak for more than 100 miles ere it emerges from the gorges of the Shakh-i-Barant to join the Kabul in the plain that stretches to Butkak. The valleys of the Logar are amongst the richest and most picturesque of Afghanistan. The united streams pass from the Kabul plain (6900 feet) through a precipitous gorge into the lower level of the Doaba to the north of the Kabul-Lataband road, and do not touch the road again till they pass Jalalabad. Meanwhile the volume of the river has been swelled at Doaba by the Tagao, which carries the drainage of the eastern slopes of the Hindu Kush from the head of the Panjshir, at the Khawak pass (11,640 feet) to the sources of the Ghorband, near the junction of the Hindu Kush with the Koh-i-Baba. Into the Tagao fall the rivers and streams of the Koh Daman north of Kabul, as well as those of a considerable section of Kohistan, which forms Western Kafiristan; so that the Tagao affluents combined present probably a greater volume than the Kabul, at Doaba. Before reaching Jalalabad the Kabul receives another great contribution from the north in the united waters of the Alingar and the Alishang, which, under the former name, join in the Laghman plain. These two rivers between them drain all Central Kafiristan south of the Hindu Kush, and unite with the main channel of the Kabul in a broad clear stream which gives little indication of its mountain origin. Very little is known about the catchment areas of these two rivers. It is a vast wilderness of mountains, the gates of which are jealously guarded by the Afghan Government; but the lower reaches of the Alingar pass through comparatively open plains, and are fringed with flourishing villages. The Laghman (or Lamghân) plain is important as indicating the ancient route from Kabul to India, which, instead of passing through Nangrahar and Jalalabad, followed the course of the Kabul river through this plain into the Kunar valley, and thence passed into Bajaor, and was carried by one of several frontier passes into the plains of Peshawur. The Khaibar is a modern route, regarded as a main line of communication. The southern affluents of the Kabul river are insignificant; but two other great tributaries from the north—the Kunar, or river of Chitral, and the Swat (with its Panjkora affluent)—have been thoroughly examined. Only about one-third of the total length of the Kunar (270 miles from Lake Karambar on the Hindu Kush to Jalalabad) is within the limits of Afghanistan. The new political boundary crosses the valley at Arnawai, near the junction of the Bashgol river of Kafiristan with the Kunar. Above this point Chitral intervenes between Afghanistan and the Gilgit province of Kashmir. Below it the eastern water-divide of the river shuts off Bajaor. The extreme narrowness of the river basin is remarkable, there being no considerable affluent from either side except the Bashgol, whilst the craggy ranges which intervene between the stream and the Panjkora on the east (or again between the Panjkora and Swat rivers), although of enormous altitude (from 12,000 to 15,000 feet), stand on a base which averages less than 25 miles. Nearly due east of Chitral the culminating peaks overlooking the sources of the Panjkora to the south, and those of the Gilgit river to the east, rise to nearly 19,000 feet of altitude.



Walker & Cockerell sc.

Sketch Map of Afghanistan.

The Swat and Panjkora river basins belong to the Cis-Afghan independent territory, which was largely exploited during the recent north-western expeditions. Their main characteristics are those of the Kunar; but they rise far to the south of the sources of that river, the range which forms the southern water-divide of the Upper Gilgit basin enclosing those small tributaries amongst its southern spurs, which swell into big affluents ere they join these two historic streams. Much of the northern parts of their basins, including the districts of Darel and Tangir, immediately south of Gilgit, still remains to be explored. Within historic times much of the Lower Swat, Panjkora, and Kunar valleys was occupied by Kafir tribes, the limits of their occupation being traceable by the total absence of these Buddhist archæological remains which abound on all sides of the sphere of paganism.

That part of the basin of the Indus beyond the Kabul and its tributaries which appertains to Afghanistan is inconsiderable. It includes hardly more than the upper tributaries of the Gomul river, which rise in the plains between Waziristan and Ghazni, but the area of Cis-Afghan independent territory which is drained by the Indus is both extensive and politically important. Kanjut, the glacial region which gives birth to the Hunza river; the valleys of Yassin and of the Upper Gilgit; a long strip of territory adjoining the Indus—the region to which the name Kohistan is frequently given—all this independent territory forms a northern section of the Indus basin apart from the Kabul tributaries. Farther south the rivers of the frontier—the Kuram, the Tochi, the Gomal, and others between these, too many to enumerate—all drain downwards from the Afghan frontier through the independent strip of mountain barrier to effect (where the intervening sands permit) a junction with the Indus.

As all this country has been geographically surveyed, the outline of the disjointed hydrographical network which forms the western catchment of the Indus between Attok and the Gomul (where the political boundary of Baluchistan intervenes) may be best studied on the maps of the Indian Survey. The frontier valleys belong to two distinct geological types. They are either deep, steep-sided valleys, with rapid streams carrying quantities of debris, or, where the upheaval of the river bed has been too rapid for the cutting-down action of the river, and the grade has been lessened, an alluvial plain has been formed, which affords a broad, open, and gently-rising ramp leading up to the Afghan plateau. Such are the valleys of the Kuram and the Tochi. The general flow of all these frontier affluents of the Indus from the Afghan plateau to the plains of the Derajat is directly across the axis of the minor frontier ranges, which lie packed in parallel lines of ridge and furrow, forming a series of grades, or steps, from the lower to the higher level. The streams rise on the plateau west of, and beyond, the prominent line of highest elevation, breaking straight through the hard sandstone or limestone ranges, and forming deep gorges where they pass; whilst their tributaries, joining almost at right angles in long narrow lateral valleys, wash the softer clays and shales from off the surface of the harder rocks, and carry down the debris to assist in grinding through the limestone barriers. The frontier hills between the Gomul and the Kuram present many instances of such narrow gateways to the Afghan highlands; to the south of the Gomul they form the most prominent type of opening into the hills.

Two important river basins of Afghanistan, belonging to that central system which has no connexion with the sea, have been examined, and many interesting facts connected with them remain to be recorded. The Hari Rud, or river of Herat, which loses itself in the Tejend oasis north of the Trans-Caspian Railway, and west of Merv, rises in the western slopes of the Koh-i-Baba, the mountain mass which abuts on, and closes, the Hindu Kush to the west of Kabul. It runs a remarkably straight course westward through a narrow trough from Daolatyar to Obeh. This trough lies between the southern ridge of the great Central Afghan watershed, which holds the head-waters and sources of the Murghab on the north, and the narrow water-parting formed by the Band-i-Baián and Koh-i-Sufed on the south. From this latter divide the tributaries of the Farah Rud and other rivers of the Sistan basin take their rise. The deeply-eroded valley of the Hari Rud, filled in with the detritus washed down by periodical floods from the soft loess formations of sand and clay which enclose it, is of great fertility in its lower and wider reaches between Obeh and Kuhsan, 50 miles west of Herat; but its upper course is barren and sand-spread, winding amidst the bleak wind-swept uplands of the highest central elevations in Afghanistan. The most notable features about the Lower Hari Rud are the absolute exhaustion of its waters in the early summer seasons of irrigation, and the rapidity with which natural processes of denudation are lowering its bounding watersheds. Immediately north of Herat the central water-divide, which is locally known by the name of Siah Bubuk (but to which the general term Paropamisus has been given in order to preserve a historical designation which belongs more correctly to the Hindu Kush), is being reduced so rapidly to a final stage of rounded curves and gentle declivities that it is already possible to drive a wheeled carriage across it without any preliminary road-making. The sources of the Helmand, like those of the Hari Rud, lie in the recesses of the Koh-i-Baba to the west of Kabul, its infant stream parting the Unai pass from the Irak, the two chief passes on the well-known road from Kabul to Bamian. For fifty miles from its source its course is ascertained, but beyond that point for the next fifty no European has followed it. About the parallel of 33° N. lat. it enters the Zamindawar province, which lies to the north-west of Kandahar, and thenceforward it is a well-mapped river to its termination in the Lagoons, or Hamún, of Sistan. This great central depression, which is about 1700 feet above sea-level, also receives the waters of several northern affluents, of which the Harut, the Farah, and the Khash are the principal. They drain the highlands occupied by the Taimani section of the Chahar Almák. About the upper affluents of the Farah lie the fertile valleys which surrounded Taiwara, the capital of the ancient kingdom of Ghor, and here the Taimani highlands culminate in peaks rising to a height of over 12,000 feet above sea-level. For 200 miles due east of Taiwara there stretches a region of barren highland desolation marked by peaks of 11,000 to 13,000 feet, the home of the Hazaras. Herein is enclosed a northern section of the valley of the Helmand, and in this portion of the valley is situated Ghizao, marking a great road from north to south. No other place of any significance is known in this region. All these northern affluents of the Sistan Hamúns partake more of the nature of highland rivers than the broad and comparatively placid Helmand. Throughout its great southern curve the Helmand shapes an even and solitary course, receiving no contributions from either side, through a valley which is exceedingly narrow, but fertile and green, and full of the last relics of departed townships belonging to that Kalani kingdom which once centred on Kala Fath. From the Helmand, near its great bend northwards, a most extensive system of irrigation was once devised, a system which watered hundreds of square miles of now barren plain to the west.

A noteworthy feature of the Sistan lagoon is that in times of excessive flood it overspreads a vast area of country, both to the north and south, shutting off the capital of Sistan (Nasirabad) from surrounding districts, and spreading through a channel southwards known as Shelag to another great depression called the Gand-i-Zirreh. This great salt swamp is about 1000 feet lower in elevation and is situated so close to the Helmand as to leave but a few miles of broken ridge between. By that ridge all communication with Sistan must pass in time of flood. Sistan becomes a promontory connected with the desert south of the Helmand by that isthmus alone. Recent boundary proceedings have included it within the Amir's territory. The Afghan basin of the Oxus includes a part of the Pamirs and all Badakshan and Afghan Turkestan. Badakshan is drained by two main rivers—the Kokcha (or river of Faizabad) and the Khanabad, which takes its name from a town on its banks. Above the Kokcha junction the Oxus is a mountain-bred river, receiving no contributions of any importance from the Afghan side. Below the Khanabad the Oxus is a river of the plains; and as far as Khamiab, where it ceases to be the boundary of Afghanistan, no Afghan river of any importance reaches it. The Tashkurghan river, the Band-i-Amir or Balkh river, the Shiburghan, and the Andkhui, all start for it, bringing down snow-fed torrents from the Koh-i-Baba, and Band-i-Turkestan in spring, and tailing off into the countless irrigation channels in the Balkh plain; but neither in winter nor in summer do any of them cross the fringe of sand desert that lies south of the Oxus river in cultivation. This appears to be due to the alteration of the plain levels by a gradual process of upheaval quite as much as to the absorption of the water-supply in irrigation. Where these rivers run into irrigation the plain is highly cultivated; but the Oxus itself is no longer utilized for agricultural purposes, except within a comparatively narrow fringe. This fringe is, however, of considerable local importance (see OXUS). On the western borders of Afghan Turkestan the Murghab river and the Hari Rud lose themselves in the Merv and Tejend oases. The Murghab starts from the Firozkhoi highlands (the northern scarp of which is defined by the Band-i-Turkestan), and, after traversing that plateau from east to west, it turns north through deeply-cut defiles to Bala Murghab, and effects a final junction with the Kushk near Panjdeh. At Bala Murghab the valley is open, with the loess formation of the Chul bounding it on either hand. Beyond Panjdeh it emerges into the Yuletan desert.

Mountain Systems.—The dominant mountain system of Afghanistan is the Hindu Kush, and that extension westwards of its water-divide which is indicated by the Koh-i-Baba to the north-west of Kabul, and by the Firozkhoi plateau (Karjistan), which merges still farther to the west by gentle gradients into the Paropamisus, and which may be traced across the Hari Rud to Mashad.

The culminating peaks of the Koh-i-Baba overlooking the sources of the Hari Rud, the Helmand, the Kunduz, and the Kabul, very nearly reach 17,000 feet in height (Shah Fuladi, the highest, is 16,870), and from them to the south-west long spurs divide the upper tributaries of the Helmand, and separate its basin from that of the Farah Rud. These spurs retain a considerable altitude, for they are marked by peaks exceeding 11,000 feet. They sweep in a broad band of roughly parallel ranges to the south-west, preserving their general direction till they abut on the Great Registan desert to the west of Kandahar, where they terminate in a series of detached and broken anticlinals whose sides are swept by a sea of encroaching sand. The long, straight, level-backed ridges which divide the Argandab, the Tarnak, and Arghastan valleys, and flank the route from Kandahar to Ghazni, determining the direction of that route, are outliers of this system, which, geographically, includes the Khojak, or Khwaja Amran, range in Baluchistan.

North of the main water-divide of Afghanistan the broad synclinal plateau into which the Hindu Kush is merged is traversed by the gorges of the Saighan, Bamian, and Kamard tributaries of the Kunduz, and farther to the west by the Band-i-Amir or Balkh river. Between the debouchment of the Upper Murghab from the Firozkhoi uplands into the comparatively low level of the valley above Bala Murghab, extending eastwards in a nearly straight line to the upper sources of the Shiburghan stream, the Band-i-Turkestan range forms the northern ridge between the plateau and the sand formations of the Chul. It is a level, straight-backed line of sombre mountain ridge, from the crest of which, as from a wall, the extraordinary configuration of that immense loess deposit called the Chul can be seen, stretching away northwards to the Oxus—ridge upon ridge, wave upon wave, like a vast yellow-gray sea of storm-twisted billows. The Band-i-Turkestan anticlinal may be traced eastwards of the Balkh-ab (the Band-i-Amir) within the folds of the Kara Koh to the Kunduz, and beyond; but the Kara Koh does not mark the northern wall of the great plateau nor overlook the sands of the Oxus plain, as does the Band-i-Turkestan. Here there intervenes a second wide synclinal plateau, of which the northern edge is defined by the flat outlines of the Elburz to the south of Mazar-i-Sharif, and immediately at the foot of this range lie the alluvial flats of Mazar and Tashkurghan. Opposite Tashkurghan the Oxus plain narrows to a short 25 miles. On the south this great band of roughly undulating central plateau is bounded by the Koh-i-Baba, to the west of Kabul, and by the Hindu Kush to the north and north-east of that city. Thus the main routes from Kabul to Afghan Turkestan must cross either one or other of these ranges, and must traverse one or other of the terrific defiles which have been carved out of them by the upper tributaries of the rivers running northwards towards the Oxus. Probably in no country in the world are there gathered together within comparatively narrow limits so many clean-cut waterways, measuring thousands of feet in depth, affording such a stupendous system of narrow roadways through the hills.

After the Hindu Kush and the Turkestan ranges, that of the Safed Koh, which divides Ningrahar (or the valley of Jalalabad) from Kuram and the Afridi Tirah, is the most important, as it is the most impressive, in Afghanistan. But the general features of the Safed Koh have been sufficiently described already, and it only remains to illustrate its configuration in relation to the mountain systems about Kabul, and south of Peshawur. The highest peak of the Safed Koh, Sikaram, is 15,600 feet above sea-level. From this central dominating peak it falls gently towards the west, and gradually subsides in long spurs, reaching to within a few miles of Kabul and barring the road from Kabul to Ghazni. At a point which is not far east of the Kabul meridian an offshoot is directed southwards, which becomes the water-parting between the Kuram and the Logar at Shutargardan, and can be traced to a connexion with the great watershed of the frontier dividing the Indus basin from that of Helmand. This main watershed retains its high altitude far to the south. There are peaks measuring over 12,000 feet on the divide between the Tochi and the Ghazni plains. At the eastern extremity the Safed Koh splits and spreads into several branches. Between these branches are the Bazar valley; the Bara, which receives the Maidán drainage; the Khanke, and other lesser valleys. The Afridi Tirah is but an upland basin held within the arms of some of the minor Safed Koh spurs, which, from the peculiarity of its formation and its narrow drainage outlet, contains a vast depth of highly fertile alluvial soil.

Between the Safed Koh and the Gomul (where lies the official boundary of Baluchistan) the frontier mountain system is more irregular than it is south of that river, where an invariable system of close parallel flexures predominates. The first developments of this system are recognizable in the long straight ridges trending from north-east to south-west, which may be seen to the west of the peaks heading the Waziri group, forming the dividing line of the Indus basin. But this configuration is not so apparent in the Waziri hills or in those between the Kuram and the Kaitu, where the mountains are massed in more independent and isolated groups, facing steeply westwards and culminating on their western summits in peaks 11,600 feet above sea-level. But the same conformation of crumpled limestone ridges, overlaid with Tertiary deposits, which pervades all Afghanistan and Baluchistan, prevails also throughout Waziristan and determines its general outlines. The extension of a long ridge towards the Indus, which curves in a grand sweep northwards overlooking the river, introduces a welcome break into the monotonous regularity of frontier scenery. On this ridge is the frontier hill station of Sheikh Budin.

Geology.—So far as we know at present the geological history of Afghanistan differs widely from that of India. When, somewhere at the commencement of the Cretaceous period, the peninsula of India was connected by land with Madagascar and Southern Africa, all Afghanistan, Baluchistan, and Persia formed part of an area which was not perhaps continuously below sea-level, but which exhibited alternations of land and sea. The end of the Cretaceous period saw the commencement of a series of great earth movements ushered in by volcanic eruptions on a scale such as the earth has never since witnessed, which resulted in the upheaval of the Himalaya by a process of crushing and folding of the sedimentary rocks till marine fossils were forced to an altitude of 20,000 feet above the sea. It was not till the Tertiary age, and even late in that age, that much of the land area of Afghanistan was raised above the sea-level. Then the ocean gradually retired into the great Central Asian depressions.

Everywhere there have been great and constant changes of level since that period, and the process of flexure and the formation of anticlinals traversing the northern districts of Afghanistan is a process which is still in action. So rapid has been the land elevation of Central Afghanistan that the erosive action of rivers has not been able to keep pace with that of upheaval; and the result all through Afghanistan (but specially marked in the great central highlands between Kabul and Herat) is the formation of those immensely deep gorges and defiles which are locally known as "daras." One of these, in the Astarāh, to the south-east of Maimana, is but 30 yards wide, and is enclosed between perpendicular limestone cliffs 1500 feet high. Throughout Afghan Turkestan and Afghanistan the lowest beds belong to a marine Carboniferous era. These are overlaid by a long succession of strata, partly marine and partly fluviatile, forming an unbroken series up to Jurassic times. On the upturned and denuded edges of these strata enormously thick beds of Cretaceous limestone rest unconformably; above these, again, marine and freshwater deposits are spread. Griesbach considers that the general outline of the land configuration has remained much the same since Pliocene times, and that the force which brought about the wrinkling of the older deposits still continues to add fold on fold. The highlands which shut off the Turkestan provinces from Southern Afghanistan have afforded the best opportunities for geological investigation, and, as might be expected from their geographical position, the general result of the examination of exposed sections leads to the identification of geological affinity with Himalayan, Indian, and Persian regions. The general configuration of the Turkestan highlands has been already indicated. Against the last great fold which terminates this mountain area northwards are ranged the Tertiaries and recent deposits. North of Maimana they form low undulating loess hills, in which most of the Band-i-Turkestan drainage is lost. This wide-spreading loess area, formed partly of wind-blown sand and partly of detritus from the mountains, is known as Chul, and merges into the great plains south of the Oxus river, a great part of which is covered with modern aerial deposits. Beneath this Chul formation the older beds of the outer and Turkestan ranges dip and pass to an irregular outcrop near the banks of the Oxus. Between the Oxus and the hills there has already been formed a rise or flexure in the ground, which extends more or less parallel to the northern edge of the hills, and, shutting in the cultivated area of the plains, arrests all tributaries seeking to effect a junction with the Oxus from the south, and leads to the formation of marshes and swamps. This appears to be the commencement of a new anticlinal which has altered the levels of the Balkh plain, and is indicative of those elevating processes which may have been effective within historic times in changing the climate and the agricultural prospects of this part of Central Asia. The Oxus itself is steadily encroaching on its right banks and depositing detritus on the left.

No fresh discoveries of minerals likely to be of high economic value to Afghanistan have been made of late years. Such as are known and worked at present have been worked from very ancient times, and their capacity is not likely to develop greatly under the Kabul Government. The most important feature in this connexion which was noted by the geologist of the Russo-Afghan Commission is the existence of vast coal beds in Northern Afghanistan.

There are no glaciers now to be found in Afghan Turkestan; but evidences of their recent existence are abundant. The great boulder bed terraces in some of the valleys of the northern slopes of the Ferozkhoi plateau are probably of glacial origin. In the mountains west of Kabul glaciers have retired, leaving the moraines perfectly undisturbed. They were probably cotemporary with the older alluvia.

Climate.—Over an area so large as Afghanistan, involving such varied conditions of geographical conformation, we find, as we might expect, a varied climatic record. Taking the highlands of the country as a whole, there is no great difference between the mean temperature of Afghanistan and that of the lower Himalaya. Each may be placed at a point between 50° and 60° F. But the remarkable feature of Afghan climate (as also of the climate of Baluchistan) is its extreme range of temperature within limited periods. The least daily range in Northern Afghanistan is in the cold weather, the greatest in the hot. For seven months of the year (from May to November) this range exceeds 30° F. daily. The coldest month of the year is February, the mean minimum being 17° F., and the maximum 38°, in the northern Herat districts. Waves of intense cold occur, lasting for several days, and one may have to endure a cold of 12° below zero, rising to a maximum of 17° below freezing-point. The eastern reaches of the Hari Rud river are frozen hard in winter, rapids and all, and the people travel on it as on a road. On the other hand the summer temperature is exceedingly high, especially in the Oxus regions, where a shade maximum of 110° to 120° is not uncommon. Afghanistan lying outside monsoon influences, there are steadier weather indications than there are in India. The north-west blizzards which occur in winter and spring are the most noticeable feature, and their influence is clearly felt on the Indian frontier. The cold is then intense and the force of the wind cyclonic. It was a blizzard of this nature which proved so disastrous to the Afghan Boundary Commission in April 1885.

Political Boundaries.—In the realm of political geography, whilst no great changes have lately been effected in the political status of Afghanistan as an independent state subject to British suzerainty, more exact definition has been given to the extent of territory under Kabul rule; and the geographical limits of the Amir's responsibility have been more distinctly laid down by the delimitation of boundaries. These delimitations commenced with the Russo-Afghan Commission of 1885, and they concluded with the Mohmand expedition of 1897, at the close of a long series of disjointed efforts arising out of the agreement signed at Kabul in November 1893.

Commencing with the Persian border at Zolfikar on the Hari Rud river, the boundary between Afghanistan and Russia follows a line roughly parallel to the course of the Paropamisus, and about 35 miles to the north of it, till it strikes the Kushk river in Jamshidi territory at a point which was once known as Chahil Doktaran, but is now the Russian station of Kushk, and the terminus of a branch railway from Merve. The Russian Kushk is about 20 miles below the old Jamshidi settlement of the same name, itself about 15 miles north of the crest of the Paropamisus. The height of the Russian station is about 2000 feet above sea, and there is a rise of 4000 feet to the crest of the Paropamisus. From here to Herat (roughly 25 miles) the fall is about 3500 feet. From Kushk the boundary runs north-east, crossing the Murghab near Maruchak (which is an Afghan fortress), and thence passes north-east through the loess hills of the Chul, and the undulating deserts of the Aleli Turkmans, to the Oxus, leaving the valleys of Charshamba and of the Andkhui (to which it runs approximately parallel) within Afghan limits. These valleys denote the limits of cultivation in this direction. Throughout all this region the boundary is generally of an artificial character, marked by pillars, but it is here and there indicated by natural features forming local lines of water-parting or water-course. The boundary meets the Oxus at Khamiab at the western extremity of the cultivated district of Khwaja Salar, and from that point to the eastern end of Lake Victoria in the Pamirs the main channel of the Oxus river forms the northern limits of Afghanistan (see OXUS). Eastwards from Lake Victoria the frontier line was determined by the Pamir Boundary Commission in 1895. A part of the little Pamir is included in Afghan territory, but the boundary crosses this Pamir before the great bend northwards of the Aksu takes place, and, passing over a series of crags and untraversable mountain ridges, is lost on the Chinese frontier in the snowfields of Sarikol. Bending back westwards upon itself, the line of Afghan frontier now follows the water-parting of the Hindu Kush; and as the Hindu Kush absolutely overhangs the Oxus nearly opposite Ishkamish, it follows that, at this point, Afghanistan is about 10 miles wide. Thus a small and highly elevated portion of the State extends eastwards from its extreme north-eastern corner, and is attached to the great Afghan quadrilateral by the thin link of the Panja valley. These narrow limits (called Wakhan) include the lofty spurs of the northern flank of the Hindu Kush, an impassable barrier at this point, where the glacial passes reach 19,000 feet in altitude, and the enclosing peaks 24,000 feet. The backbone or main water-divide of the Hindu Kush continues to form the boundary between Afghanistan and those semi-independent native states which fringe Kashmir in this mountain region, until it reaches Kafiristan. From near the Dorah pass (14,800 feet), which connects Chitral with the Panja (or Oxus) river, a long, straight, snow-clad spur reaches southwards, which divides the Kafiristan valley of Bashgol from that of Chitral, and this continues to denote the eastern limits of Afghanistan till it nearly touches the Chitral river opposite the village of Arnawai, 45 miles south of Chitral. Here the Bashgol and Chitral valleys unite and the boundary passes to the water-divide east of the Chitral river, after crossing it by a spur which leaves the insignificant Arnawai valley to the north; along this water-divide it extends to a point nearly opposite the quaint old town of Pashat in the Kunar valley (the Chitral river has become the Kunar in its course southwards), and then stretches away in an uneven and undefined line, dividing certain sections of the Mohmands from each other by hypothetical landmarks, till it strikes the Kabul river near Palosi. Thence following a course nearly due south, it reaches Lundi Kotal. From the abutment of the Hindu Kush on the Sarikol in the Pamir regions to Lundi Kotal, and indeed throughout its eastern and southern limits, the boundary of Afghanistan which we are describing does not part that country from British India, but from certain outlying independent frontier districts, all of which lie beyond the boundary which Britain inherited from the Sikhs, and which is still recognized as the limit of British India. Kanjut, Chitral, Bajaor, the Mohmand districts, Swat, and Buner are all included in this fringe of quasi-independent territory, which, although the degree of independence enjoyed by it is of a different character altogether from that enjoyed by Afghanistan (being more immediately under British political control), has never yet been included within the red line. From the neighbourhood of Lundi Kotal the boundary is carried to the Safed Koh overlooking the Afridi Tirah, and then, rounding off the cultivated portions of the Kuram valley below the Peiwar, it crosses the Kaitu and passes to the upper reaches of the Tochi. Crossing these again, it is continued on the west of Waziristan, finally striking the Gomul river at Domandi. So far it has divided Afghanistan from the independent province of the Punjab. South of the Gomul it separates the interests of Afghanistan from those of Baluchistan. The Punjab independent provinces[1] are traversed by certain routes (the Khaibar, the Kuram, the Tochi, and the Gomul) which are held by British arms, and guarded by regulars or militia in British pay. At the western extremities of these routes India touches Afghanistan, and nowhere else. From Domandi (the junction of the Kundar river and the Gomul) the Afghan boundary marches with that of Baluchistan (see BALUCHISTAN). It is carried to the south-west on a line which is largely defined by the channels of the Kundar and the Kadanai to a point beyond the Sind Peshin terminal station of New Chaman, west of the Khojak range, and then drops southwards to Shorawak and Nushki. From Nushki it crosses the Helmand desert, touching the crest of a well-defined mountain watershed for a great part of the way, and, leaving Chagai to Baluchistan, it strikes nearly west to the Persian frontier, and joins it on the Koh-i-Malik Siah mountain, south of Sistan. Two points of this part of the Afghan boundary are notable. It leaves some of the most fanatical of the Durani Afghan people on the Baluch side of the frontier in the Toba district, north of the Quetta-Chaman line of railway; and it passes 50 miles south of the Helmand river, enclosing within Afghanistan the only approach to Sistan from India which is available during the seasons of Helmand overflow. Between Afghanistan and Persia the boundary was defined by Sir F. Goldsmid's Commission in 1872 from the Malik-Siah-Koh to the Helmand Hamúns; beyond those lagoons to the northward it is still indefinite till it touches the district of Hashtadan in lat. 34° 15′. Here again a small section of about 40 miles has been delimited as far as the Hari Rud river at Toman Agha (some 12 miles below Kuhsán), and from this point to Zulfekar the Hari Rud is itself the boundary.

Afghan Provinces.—Within the limits of this boundary the chief provinces of Afghanistan are those of Kabul, Zabul (or Kandahar), Herat, and Afghan Turkestan. The Kabul province mainly (for it is not possible to enter into details as regards these indefinite internal provincial boundaries) includes the Kabul basin, and Roh. Roh originally signified all the country of the Suliman and Khaibar hills so far as they are occupied by Pathans, *i.e.*, from Bajaor on the north to Peshin and Sibi on the south, and from the Indus to Ghazni and the Khojak in the west. The word Roh means the same as Koh (a mountain), and the Roh mountaineers are the Rohilla of history. By the late boundary demarcation a part of Roh has become independent of Afghanistan, and the name might conveniently be applied to all that independent strip of territory which now intervenes as a buffer between British India and Afghanistan. Zabul includes Sistan, and, although well enough known to Afghans, the name has been superseded in colloquial English by Kandahar. It may be said to include the Helmand basin. Herat is, broadly speaking, the basin of the Hari Rud; and Afghan Turkestan includes the plains of Balkh and Badakshán.

---

[1] These provinces have been included in a political agency distinct from the Punjab since the above was written.

Chief Cities.—The political and commercial activity of Afghanistan centres about the three cities of Kabul, Kandahar, and Herat, notices of which occur elsewhere in the *Ency. Brit.* Of other well-known cities of Afghanistan, Balkh (the mother of cities), and Ghazni are cities of the past, Mazar-i-Sharif is a religious, and Tashkurghan a commercial centre for the Oxus provinces of Afghan Turkestan. Maimana, Andkhui, Khanabad, and Faizabad are all places of note—walled towns, with local commandants, or governors, and busy, well-filled bazaars. There are, indeed, more widespread signs of general industrial activity in Afghan Turkestan than there are in the Herat and Kandahar provinces of Southern Afghanistan, where wide spaces exist which do not include a single town of importance. This is especially the case towards the western frontier, where, however, such local centres as Farah and Sabzawar, and such smaller industrial communities as Adraskand, Kin, and many other frontier villages, would undoubtedly develop into significance if encouraged by a railway.

Independent Tribes.—Collaterally with Afghanistan the political geography of that independent strip of territory which intervenes between the Afghan frontier and British India requires notice, for some of it formed part of the Afghan Durani empire, together with a large portion of the Punjab and Sind. It is only since 1896 that this independent "buffer" territory has become a political entity by the creation of the present Afghan boundary. Whether it long survives beyond the red line of the Punjab or not, assuredly it will never form part of Afghanistan again.

From the central water-divide of the Hindu Kush there reaches southwards a wide strip of mountainous country, formed by its elevated and intricate spurs, to the borders of the Peshawur plain. On the west this mountain district is bounded by Afghanistan; on the east it stretches beyond the Indus to the Khagan valley and Kashmir. This great wilderness of mountains includes the Chitral basin north of Arnawai; the valleys of Yasin, Karambar (or Ashkuman), and Hunza (the last known as Kanjut), all forming part of the Gilgit basin; a considerable section of the Indus valley, in which lie the forts of Chilas and Takot; together with the peaks of Kohistan, Darel, and Tangir; the valley of Buner; the valleys of the Swat, Panjkora, Dir, Bajaor, and a part of the Mohmand country. Some of these valleys are connected by political ties with Kashmir; others are quite independent (see GILGIT). It is nothing but a broad waste of mountains intersected by narrow rock-bound valleys, and traversed by routes which here and there are hardly distinguishable from the crudest goat-tracks. The southern part of this region, so full of geographical surprises and thorny political problems, is usually termed Yaghistan (the country of the independents) by the frontier people, and throughout these southern tracts the dominant race is that of the Afghan Yusufzai. Amongst this vast array of minor ranges, all of them offshoots of the Hindu Kush, the dividing ridge between the Gilgit drainage and the upper Chitral and Panjkora basins, which is called Shandur, is perhaps the most prominent feature. It shuts off Chitral from its base at Gilgit by a barrier which is over 12,000 feet in altitude. The alternative approach to Chitral from the south by Dir leads to no altitude greater than 10,500 feet—the height of the Lowarai pass leading from Dir to Kala Drosh. Yaghistan and the Chitral and Kanjut mountains separate British India effectually from the highlands of the Pamirs. Across that independent mountain waste no irruption into India has ever spread from the north. It forms a barrier which is practically as effective as that of Kafiristan on its western flank, and will continue to form a barrier so long as the glacier-bound passes and byways of the Hindu Kush are not improved into high-roads.

Immediately south of the Khaibar route the band of independent territory is continued by the Afridi uplands of the eastern spurs of the Safed Koh. Then occurs the Kuram valley and the irregular mountain belt occupied by the Shiah Turis and Jajis. Here once more, as at Lundi Khana, British India touches Afghanistan on the Peshawur spurs, the valley of the Kuram being held by British levies. Next there intervenes a rough independent mountainous district drained by the Kaitu, between the Kuram and Tochi, where again the British line of occupation penetrates the frontier to the Afghan boundary. Beyond this, to the south, lies the Switzerland of the frontier, Waziristan forming a separate geographical and ethnographical division from the rest of the frontier. From the Khaibar to the Gomul the characteristics of the borderland are wide, flattish valleys, with comparatively gentle gradients filling in the open spaces between hills which are gradually being lowered by processes of denudation. There is little of that marked regularity of parallel flexures which is the prevailing feature south of the Gomul.

Ethnography.—The term Afghan really applies to one section only of the mixed conglomeration of nationalities which forms the people of Afghanistan, but this is the dominant section. The predominance of the Afghan in Afghanistan dates from the middle of the 18th century, when Ahmad Shah carved out Afghanistan from the previous conquests of Nadir Shah, and called it the Durani empire.

The Afghans claim to be *Ben-i-Israel*, and insist on their descent from the tribes who were carried away captive from Palestine to Media by Nebuchadnezzar. Yet they claim to be Pukhtun (or Pathán) in common with all other Pushto-speaking tribes, whom they do not admit to be Afghan. The bond of affinity between the various peoples who compose the Pathan community is simply the bond of a common language. All of them recognize a common code or unwritten law called Pukhtunwali, which appears to be similar in general character to the old Hebraic law, though modified by Mahommedan ordinances, and strangely similar in certain particulars to Rajput custom.

Since their national independence the Afghans of Afghanistan have styled themselves *Durani*. They are settled principally in the Kandahar country, extending into Sistan and to the borders of the Herat valley. Eastward they spread across the Afghan border into the Toba highlands north of the Khojak, where they are represented by Achakzai and Sadozai clans. They exist in the Kabul districts as Barakzai (the Amir's clan), and as Mehmundzai (Mohmands) and Yusufzai they occupy the hills north of the Kabul river, Bajaor, Swat, Buner, and part of the Peshawur plains. All the newly-demarcated independent provinces north of the Peshawur, and south of the Chitral and the Gilgit basin, are peopled with Afghans who are thus outside the frontier of Afghanistan.

After the Afghan the dominant people are the *Pukhtun*, or *Pathans*, who are represented by a variety of tribes, many of which are recognized as being of Indian origin. These non-Afghan Pathans occupy the hilly regions on the immediate British frontier. The Afridi, Jowaki, and Orakzai clans hold the highlands immediately south of the Khaibar and Peshawur. The Turis of the Kuram (of the Shiah persuasion), the Dawaris of Tochi, and the Waziris of Waziristan fill up the intervening Pathan hills north of the Gomul. In the Kohat district the Khattak and Bangash clans are Pathan, so that Pathans are found on both sides of the border. Pathans are probably the Pactyii or Pactyæ of Herodotus, who also mentions the Aprytæ or Afridi. In the utter absence of written history or of trustworthy genealogical evidence, the origin of most of the Pathan clans is likely ever to remain a mystery. It is enough that we can trace their existence in the regions they now occupy, or in contiguous districts, from the days of Herodotus. The immediate connexion of Britain with the Pathan of the Indian border makes him an important item in frontier ethnography; but he is not (within the limits of Afghanistan) to be considered as a political factor of anything like equal importance with the Ghilzai.

The *Ghilzai* is reckoned a Pathan, and he is connected with the Afghan; but he is of an entirely distinct origin, and he only claims ties of faith and affinity of language with other Afghan peoples—he does not admit kinship. The popular theory of the origin of the Ghilzai traces him to the Turkish tribe of Kilji, once occupying districts bordering the upper course of the Jaxartes, and affirms that he was brought into Afghanistan by the Turk Sabaktegin in the 10th century of our era. However that may be, the Ghilzai clans now rank collectively as second to none in strength of military and commercial enterprise. They are a fine, manly race of people, and it is from some of their most influential clans (Saliman Khel, Nasir Khel, Kharotis, &c.) that the main body of povindah merchants is derived. These frontier commercial travellers trade between Ghazni and the plains of India, bringing down their heavily-laden kafilas at the commencement of the cold weather, and retiring to the hills again ere the summer heat sets in. Thousands of them may be found during the winter months circulating through the farthest districts of the peninsula, where it not infrequently happens that they prove to be troublesome, if not dangerous, visitors. The Pathan, however, who finds his way across the sea to Australia is not of the Ghilzai tribe. He usually belongs to the Kakur section of Pathans, who occupy a large district in Baluchistan. Ghilzai chiefs take a lead in the politics of the country and possess much influence at the court of Kabul.

Underlying the predominant Afghan and Ghilzai elements in Afghan ethnography is the *Tajik*, representing the original Persian possessor of the soil, who still speaks his mother tongue. There are pure Persians in Afghanistan, such as the Kizzilbashes of Kabul, and the Naoshirwanis of Kharan; but the name Tajik appears to be applied only to an admixture of original Arab and Persian stock (such as the Dehwars), who are the slaves of the community—hewers of wood and drawers of water. Everywhere the Tajiks are the cultivators in rural districts, and the shopkeepers and clerks in the towns. The Tajik is as much the slave of the Pathan in Afghanistan as is the Hindki (whose origin is similar) in the plains of the Indus. Yet the Tajik population of the richly-cultivated districts north of Kabul proved themselves to be of good fighting material in the Afghan war of 1879-80, and the few Kizzilbashes that are to be found in the ranks of the Indian army are good soldiers.

Next in importance to the Tajik is the *Mongul* Hazara, who also speaks a dialect of Persian, and belongs to the Shiah sect of Mahommedans. The Hazara are descendants of military colonists introduced by Chenghiz Khan; they occupy all the highlands of the upper Helmand valley, spreading through the country between Kabul and Herat, as well as into a strip of territory on the frontier slopes of the Hindu Kush north of Kabul. In the western provinces they are known as the Chahar Aimák (Hazaras, Jamshides, Taimanis, and Farozkhois), and in other districts they are distinguished by the name of the territory they occupy. They are pure Monguls, intermixing with no other races (chiefly for the reason that no other races will intermix with them), preserving their language and their Mongul characteristics uninfluenced by their surroundings, having absolutely displaced the former occupants of the Hazarajat and Ghor. They make good soldiers and excellent pioneers. The Amir's companies of engineers are recruited from the Hazaras, and they form perhaps the most effective corps in his heterogeneous army.

In Afghan Turkestan we find the Tajik mixed with Turkish races—the Usbak and Turkman. Much interesting literature exists about the *Turkman*, the original Turk of Asia. By some ethnographers he is associated with the red-skinned Rajput in those early days when he was known to ancient geographers as Skyth. Others see in him an offshoot from the same original sources which developed the Teuton. He is at any rate non-Mongolian, and the old race hatred between Turk and Mongul is hardly less bitter now than it was in the days of Zahir-u-din Mahommed, otherwise called Babar, the royal Turk adventurer who founded that dynasty of Turkish emperors on the throne of Delhi which has been known to posterity as "Moghul." The chief Turkman tribes left to Afghan rule are the Alieli of the Daolatabad-Andkhui districts and the Ersari of the Khwaja Salar section of the Oxus frontier. Originally robbers and raiders, they are all of them now engaged in agricultural pursuits.

North of Kabul, in the Kohistan that borders Kafiristan, are certain races of mixed origin speaking Persian dialects, such as the Nimchas, Safis, &c., who fringe round the central mountain wilderness of Kafiristan, where are to be found secluded valleys and glens containing tribes and peoples (collectively called *Kafirs*), who speak dialects innumerable, and who were till lately independent of Afghanistan. Remnants of the ancient Baktria, flotsam and jetsam from old Greek colonies, intermingled with people of Indian origin forced upwards from the plains, are all represented in the Kafiristan wilderness. The ethnography of Kafiristan still requires elucidation. The well-known claim of the Kafir to be considered as of Greek extraction is partially supported by the late identification of a tribe of Kamdesh in lower Bashgol with the ancient Nicæans of Arrian's history; and it seems probable that, with the progress of scientific investigation, recent theories of recognizable Greek elements in the population of certain districts south of Kabul will be fully sustained.

Roads and Passes.—Omitting the group of northern routes to India from Central Asia, which pass between Kashmir and Afghanistan through the defiles of Chitral and of the Indus (see HINDU KUSH), the highways of Afghanistan may be classed under two heads: (1) Foreign trade routes, and (2) Internal communications.

Of the many routes which cross the frontiers of Afghanistan the most important commercially are those which connect the Oxus regions and the Central Asian Khanates with Kabul, and those which lead from Kabul, Ghazni, and Kandahar to the plains of India. Kabul is linked with Afghan Turkestan and Badakshan by three main lines of communication across the Koh-i-Baba and the Hindu Kush. One of these routes follows the Balkh river to its head from Tashkurghan, and then, preserving a high general level of 8000 to 9000 feet, it passes over the water-divides separating the upper tributaries of the Kunduz river, and drops into the valley formed by another tributary, at Bamian. From Bamian it passes over the central mountain chain to Kabul either by the well-known passes of Irak (marking the water-divide of the Koh-i-Baba) and of Unai (marking the summit of the Sanglakh, a branch of the Hindu Kush), or else, turning eastwards, it crosses into the Ghorband valley by the Shibar, a pass which is considerably lower than the Irak and is very seldom snowbound. From the foot of the Unai pass it follows the Kabul river, and from the foot of the Shibar it follows the circuitous route which is offered by the drainage of the Ghorband valley, to Charikar, and thence southwards to Kabul. The main points on this route are Haibak, Bajgah, and Bamian. It is full of awkward grades and minor passes, but it does not maintain a high level generally, no pass (if the Shibar route be adopted) much exceeding 10,000 feet. That this has for centuries been regarded as the main route northward from Kabul, the Buddhist relics of Bamian and Haibak bear silent witness; but it may be doubted whether the Amir's talent for roadmaking has not opened out better alternative lines. One of his roads connects Haibak with the Ghorband valley by the Chahardar pass across the Hindu Kush. The pass is high (nearly 14,000 feet), but the road is excellently well laid out, and the route, which, south of Haibak, traverses a corner of the Ghori and Baghlan districts of Badakshan, is more direct. A third route also passes through Badakshan, and connects Kunduz with Charikar by the Khawák pass and Panjshir river. The latter joins the Ghorband close to Charikar. The Khawák (11,600 feet) is not a high pass; the grades are easy and the snowfall usually light. This high road is stated (on Afghan authority) to be kept open for khafila traffic all the year round by the employment of forced labour for clearing snow. It is a recently-developed route and one of great importance to Kabul, both strategically and commercially. Routes passing westwards to the Afghan highlands through the mountain barriers of the frontier between Peshawur and the Gomul occur at intervals along the western border, and in this northern section of the north-west frontier they are all well marked. The Khaibar, Kuram, and Tochi are the best known, inasmuch as all these lines of advance into Afghanistan are held by British troops or Indian levies. But the lately-explored Bara valley route into the heart of the Afridi Tirah is not to be altogether overlooked, although it is not a trade route of any importance. The *Khaibar route* is described elsewhere. It should be noted that it was not in ancient times the main route of advance from Kabul to Peshawur. From Kabul the old route followed the Kabul river through the valley of Laghman (or Lamghan, as the Afghans call it) over a gentle water-parting into the Kunar valley, leaving Nangrahar and Jalalabad to the south. From the Kunar it crossed into Bajaor by one of several open and comparatively easy passes, and from Bajaor descended into India either by the Malakand or some other contiguous frontier gateway to the plains of Peshawur. The *Kuram route* involves the Peiwar and the Shutargardan passes (8600 and 10,800 feet respectively) across the southern extensions of the Safed Koh range, and has never been a great trade route, however suitable as an alternative military line of advance. Although trade at present does not extend largely between Afghanistan and India by the Tochi route, being locally confined to the valley and the districts at its head, yet this is the shortest and most direct route between Ghazni and the frontier, and in the palmy days of Ghazni raiding was the road by which the great robber Mahmud occasionally descended on to the Indus plains. Traces of his raiding and roadmaking are still visible, but it is certain that he made use of the more direct route to Peshawur far more frequently than he did of the Tochi. The exact nature of the connexion between the head of the Tochi and the Ghazni plain is still unknown to us. The *Gomul* is, and has ever been, the great central trade route between Afghanistan and India; and the position, which has lately been occupied by a British post at Wana, will do much to ensure its continued popularity. The Gomul involves no passes of any great difficulty, although it is impossible to follow the actual course of the river on account of the narrow defiles which have been cut through the recent conglomerate beds which flank the plains of the Indus. It has been carefully surveyed for a possible railway alignment; and an excellent road now connects Tank (at its foot) with the Zhob line of communications to Quetta, and with Wana on the southern flank of Waziristan. The Gomul route is of immense importance, both as a commercial and strategic line, and in both particulars is of far higher significance than either the Kuram or the Tochi.

Of the interior lines of communication, those which connect the great cities of Afghanistan, Herat, Kabul, and Kandahar are obviously the most important. Between Kabul and Herat there is no "royal" road, the existing route passing over the frequently snowbound wastes that lie below the southern flank of the great Koh-i-Baba into the upper valleys of the Hari Rud tributaries. It is a waste, elevated, desolate region that the route traverses, and the road itself is only open at certain seasons of the year. Between Kabul and Kandahar exists the well-known and oft-traversed route by Ghazni and Kalat-i-Ghilzai. There is but one insignificant water-parting—or kotal—a little to the north of Ghazni; and the road, although unmade, may be considered equal to any road of its length in Europe for military purposes. Between Kandahar and Herat there is the recognized trade route which crosses the Helmand at Girishk and passes through Farah and Sabzawar. It includes about 360 miles of easy road, with spaces where water is scarce. There is not a pass of any great importance, nor a river of any great difficulty, to be encountered from end to end, but the route is flanked on the north between Kandahar and Girishk by the Zamindawar hills, containing the most truculent and fanatical clans of all the Southern Afghan tribes. Little need be said of the 65 miles of route between Kandahar and the Baluchistan frontier at New Chaman. It is on the whole a route across open plains and hard, stony "dasht"—a route which would offer no great difficulties to that railway extension from Chaman which has so long been contemplated. A very considerable trade now passes along this route to India, in spite of the almost prohibitive imposts of the Amir; but the trade does not follow the railway from New Chaman to the eastern foot of the Khojak. This part of the line is officially "boycotted" by the court at Kabul, and long strings of camels may still be seen from the train windows patiently treading their slow way over the Khojak pass to Kila Abdullah, whilst the train alongside them rapidly twists through the mountain tunnel into the Peshin valley.

Statistics.—No trustworthy statistics exist showing either present numbers or fluctuations in the population of Afghanistan. Within the Amir's dominions there are probably from four to five millions of people, and of these the vast majority are agriculturists.

The cultivators, including landowners, tenants, hired labourers, and slaves, represent the working population of the country, and as industrious and successful agriculturists they are unsurpassed in Asia. They have carried the art of irrigation to great perfection, and they utilize every acre of profitable soil. Certain Ghilzai clans are specially famous for their skill in the construction of the karez or underground water-channel. There are two harvests in most parts of Afghanistan; the first (consisting of cereals and some peas and beans) is reaped in summer, and the second in autumn, when rice, millet, arzun (panicum halicum), and Indian corn ripen. Vast quantities of fruit are grown and exported to India from both Kabul and Kandahar. Assafœtida is indigenous to the western districts and also forms a considerable item of export.

The manufactures of the country have not developed much during recent years. Postins (sheepskin clothing) and the many varieties of camel and goat's hair-cloth which, under the name of "barak," "karak," &c., are manufactured in the northern districts, are still the chief local products of that part of Afghanistan. Herat and Kandahar are famous for their silks, although a large proportion of the manufactured silk found on the Herat market, as well as many of the felts, carpets, and embroideries, are brought from the Central Asian khanates. The district of Herat produces many of the smaller sorts of carpets ("*galichas*" or prayer-carpets), of excellent design and colour, the little town of Adraskand being especially famous for this industry; but they are not to be compared with the best products of Eastern Persia or of the Turkman districts about Panjdeh.

The nomadic Afghan tribes of the west are chiefly pastoral, and the wool of the southern Herat and Kandahar provinces is famous for its quality. In this direction, the late boundary settlements have undoubtedly led to a considerable development of local resources. A large quantity of wool, together with silk, dried fruit, madder, and assafœtida, finds its way to India by the Kandahar route.

It is impossible to give accurate trade statistics, there being no trustworthy system of registration. The value of the imports from Kabul to India in 1892-93 was estimated at 221,000 Rx (or tens of rupees). In 1899 it was little over 217,000 Rx, the period of lowest intermediate depression being in 1897. These imports include horses, cattle, fruits, grain, wool, silk, hides, tobacco, drugs, and provisions (ghi, &c.). All this trade emanates from Kabul, there being no transit trade with Bokhara owing to the heavy dues levied by the Amir. The value of the exports from India to Kabul also shows great fluctuation. In the year 1892-3 it was registered at nearly 611,000 Rx. In 1894-5 it had sunk to 274,000 Rx, and in 1899 it figured at 294,600 Rx. The chief items are cotton goods, sugar, and tea. In 1898-99 the imports from Kandahar to India were valued at 330,000 Rx, and the exports from India to Kandahar at about 264,000 Rx. Three-fourths of the exports consist of cotton goods, and three-eighths of the imports were raw wool. The balance of the imports was chiefly made up of dried fruits. Comparison with trade statistics of previous years on this side Afghanistan is difficult, owing to the inclusion of a large section of Baluchistan and Persia within the official "Kandahar" returns; but it does not appear that the value of the Western Afghanistan trade is much on the increase. The opening up of the route between Quetta and Sistan has doubtless affected a trade which was already seriously hampered by the Amir's short-sighted restrictions.

The Government of Afghanistan is monarchical, and succession to the throne is hereditary. There are five chief political divisions in the country—namely, Kabul, Turkestan, Herat, Kandahar, and Badakshan, each of which is ruled by a "naib" or governor, who is directly responsible to the Amir. Under the governors of provinces the nobles and kazis (or district judges) dispense justice much in the feudal fashion. Apart from the universal system of bribery and spoliation to which they give rise, feudal methods are more popular (and possibly more effective with a people like the Afghans) than high courts and the slow machinery of civil law would be. Swift even-handed justice is by no means rare in Afghanistan.

The Afghan army probably numbers nearly 50,000, distributed between the military centres of Herat, Kandahar, Kabul, Mazar-i-Sharif, Jalalabad, and Asmar, with detachments at frontier outposts on the side of India. The Amir's factories at Kabul for arms and ammunition are said to turn out about 20,000 cartridges and 15 rifles daily, with 2 guns per week; but it is probable that means are available for the acquisition of other military equipment than that manufactured in the country.

Financially, Afghanistan has never, since it first became a kingdom, been able to pay for its own government, public works, and army. There appears to be no inherent reason why this should be so. Whilst it can never (in the absence of any great mineral wealth) develop into a wealthy country, it can at least support its own population; and it would, but for the short-sighted trade policy of the Amir, certainly have risen, during the last twenty years of peace, to a position of respectable solvency. Its revenues (about which no trustworthy information is available) are subject to great fluctuations, and probably never exceed the value of one million sterling per annum. They fell in Sher Ali's time to £700,000. The original subsidy to the Amir from the Indian Government was fixed at 120,000 Rx per annum, but in 1893 in connexion with the boundary settlement it was increased to 180,000 Rx.

The religion of the country throughout is Mahommedan. Next to Turkey, Afghanistan is the most powerful Mahommedan kingdom in existence. The vast majority of Afghans are of the Sunni sect; but there are, in their midst, such powerful communities of Shiahs as the Hazaras of the central districts, the Kizzilbashes of Kabul, and the Toris, or Turis, of the Kuram border, nor is there between them that bitterness of sectarian animosity which is so marked a feature in India. The Kafirs of the mountainous region of Kafiristan alone are non-Mahommedan. They are sunk in a paganism which seems to embrace some faint reflexion of Greek mythology, Zoroastrian principles, and the tenets of Buddhism, originally gathered, no doubt, from the varied elements of their mixed extraction. Those contiguous Afghan tribes once included in Kafiristan, who have not so long ago been converted to the faith of Islam, are naturally the most fanatical and the most virulent upholders of the faith around them. In and about the centre of civilization at Kabul, instances of Ghazidom are comparatively rare. In the western provinces about Kandahar (amongst the Durani or true Afghans—the people who specially claim to be Beni-i-Israel), and especially in Zamindawar, the spirit of fanaticism runs high, and every other Afghan is a possible Ghazi—a man who has devoted his life to the extinction of other creeds.

Education is confined to most elementary principles in Afghanistan. Of schools or colleges for the purposes of a higher education befitted to the sons of noblemen and the more wealthy merchants, there is absolutely none; but the village school is an ever-present and very open spectacle to the passer-by. Here the younger boys are collected and instructed in the rudiments of reading, writing, and religious creed by the village mulla, or priest, who thereby acquires an early influence over the Afghan mind. The method of teaching is confined to that wearisome system of loud-voiced repetition which is so annoying a feature in Indian schools; and the Koran is, of course, the text-book in all forms of education. Every Afghan gentleman can read and speak Persian, which is the language of the court, and which is, indeed, more often heard in Kabul than Pushtu; but beyond this acquirement (to which must certainly be added the arts and graces of good manners) education seems to be limited to the physical development of the youth by instruction in horsemanship and feats of skill. Such advanced education as exists in Afghanistan is centred in the priests and physicians; but the ignorance of both is almost phenomenal.

AUTHORITIES.—Since Afghanistan has been mapped and surveyed no comprehensive account of the country has been published. Apart from the survey reports and gazetteers of the Indian Government, the following are the chief recent sources of information:—KAYE. *History of the War in Afghanistan*, 1878.—MALLESON. *History of Afghanistan*. London, 1879.—W. P. SIMPSON. "Jalalabad Region," *R.G.S. Proc.*, vol. i. 1879.—Dr H. W. BELLEW. *Afghanistan and the Afghans*. London, 1879; "The Ethnography of Afghanistan," *Asiatic Quarterly Review*, Oct. 1891.—Major HOLDICH. "Geographical Results of the Afghan Campaign," *R.G.S. Proc.*, vol. i. 1879.—HENSMAN. *The Afghan War*. London, 1881.—Major W. BROADFOOT. "Reports on Part of the Ghilzai Country," supplementary paper, *R.G.S.*, vol. i. Part III. 1885.—C. L. GRIESBACH. "Afghan and Persian Field Notes," *Geol. Survey of India*, vol. xix. Part I. 1886; "Field Notes from Afghanistan," *Geol. Survey of India*, vol. xix. Part IV. 1886.—Captain A. C. YATE. *England and Russia face to face in Asia*. Edinburgh, 1887.—Major C. E. YATE. *Northern Afghanistan*. Edinburgh, 1888.—MAITLAND and TALBOT. "Journeys in Afghanistan," *R.G.S. Proc.*, vol. ix. 1887.—W. L. DALLAS. "The Climatology of Afghanistan," *J.U.S.* India, vol. xx. 1891.—OLDHAM. "Evolution of Indian Geography," *Geog. Journ.*, vol. iii. 1894.—Major H. RAVERTY. "The Independent Afghan and Pathan Tribes," *Asiatic Quarterly Review*, vol. vii. 1894.—Dr GRAY. *At the Court of the Amir*. London, 1895.—Hon. G. N. CURZON. "A Recent Journey in Afghanistan," *P.R.I.* 14, 1896.—Sir G. ROBERTSON. *The Kafir of the Hindu Kush*. London, 1896.—Sir T. HOLDICH. "The Origin of the Kafir of the Hindu Kush," *Geog. Journal*, vol. vii. 1896. (T. H. H.*)

RECENT HISTORY.

Saddozais and Bârakzais.

In following the history of the course of affairs in Afghanistan during the 19th century, it should be remembered that the Saddozais and Bârakzais are two branches of the Durani tribe, which was raised to dominant power by its chief, Ahmed Khan, the founder of an Afghan kingdom under the Saddozai dynasty towards the end of the 18th century. His descendants had ruled, amid many vicissitudes, at Kabul, until in 1818 the assassination by the reigning Amir of his powerful minister, Fatteh Khan Bârakzai, led to a revolt headed by the Bârakzai family, which ended in the expulsion of the Saddozai Shah Shujah, and the establishment at Kabul of Dost Mahommed, Fatteh Khan's son; while Shah Shujah took refuge in the Punjab. By this time the political situation of Afghanistan had become materially affected by the consolidation of a formidable military dominion on its eastern frontier in the Punjab, under Ranjit Singh and his Sikh army. Ranjit Singh took advantage of the distracted condition of Afghanistan to seize Kashmir, and in 1823 he defeated the Afghans in a battle which gave him the suzerainty of the Peshawar province on the right bank of the Indus, though an Afghan chief was left to administer it. Ten years later Shah Shujah, the exiled Saddozai Amir, made a futile attempt to recover his kingdom. He was defeated by Dost Mahommed, when Ranjit Singh turned the confusion to his own account by seizing Peshawar and driving the Afghans back into their mountains.

Shah Shujah and Dost Mahommed.

Interference of European Powers.

At this point begins the continual interference of England and Russia in the affairs of Afghanistan, which has ever since exercised a dominant influence upon all subsequent events and transactions. It has not only transformed the situation of the ruling Amirs, but has also profoundly affected the Asiatic policy of the two European Governments. Shah Shujah's enterprise in 1833 had been supported by the co-operation of Ranjit Singh, and encouraged by the British Viceroy, Lord W. Bentinck. Although the expedition failed, the result was to excite jealousy of the British designs; and the Russian envoy at Tehran instigated the Shah of Persia to attack Herat, the important frontier fortress of north-western Afghanistan, which was then in the possession of an independent chief. In 1837, in spite of remonstrances from the British representative at Tehran, a Persian army besieged the city, but the appearance of British troops on the southern coast of Persia compelled the Persians to withdraw from Herat in 1838. The rivalry between England and Russia was now openly declared, so that each movement from one side was followed by a counter move on the Afghan chess-board from the other side. The British ministry had been seriously alarmed at the machinations of Russia and the attitude of Dost Mahommed at Kabul; and it was determined that the most effective means of securing their own interests within the country would be by assisting Shah Shujah to recover his sovereignty. A tripartite treaty was made between Ranjit Singh, the British Governor-General of India, and Shah Shujah; and a British army marched up the Bolan Pass to Kandahar, occupied that city, pushed on northwards to Ghazni, which was taken by assault, and entered Kabul in 1839. As Dost Mahommed had fled across the northern mountains, Shah Shujah was proclaimed king in his stead.

British policy in Afghanistan.

But this ill-planned and hazardous enterprise was fraught with the elements of inevitable failure. A ruler imposed upon a free people by foreign arms is always unpopular; he is unable to stand alone; and his foreign auxiliaries soon find themselves obliged to choose between remaining to uphold his power, or retiring with the probability that it will fall after their departure. The leading chiefs of Afghanistan perceived that the maintenance of Shah Shujah's rule by British troops would soon be fatal to their own power and position in the country, and probably to their national independence. They were insatiable in their demands for office and emolument, and when they discovered that the Shah, acting by the advice of the British envoy, was levying from among their tribesmen regiments to be directly under his control, they took care that the plan should fail. Without a regular revenue no effective administration could be organized; but the attempt to raise taxes showed that it might raise the people; so that for both men and money the Shah's government was still obliged to rely principally upon British aid. All these circumstances combined to render the new régime weak and unpopular; since there was no force at the ruler's command except foreign troops to put down disorder or to protect those who submitted; while the discontented nobles fomented disaffection and the inbred hatred of strangers in race and religion, among the general Afghan population. The result was that after two years' occupation of the country, in the vain hope of establishing a national government under Shah Shujah, the British found their own situation untenable; for the fierce and warlike tribes broke out into incessant revolt, until a serious insurrection at Kabul in the winter of 1841-42 compelled the British army to make an ignominious and disastrous retreat. The whole force was lost on the road between Kabul and Jalalabad; but Jalalabad was successfully defended by its British garrison, and General Nott held out at Kandahar until General Pollock's temporary re-occupation of Kabul in 1842 restored in some degree the military reputation of Great Britain. The British troops then completely evacuated the country. Dost Mahommed, who had been a state prisoner in India, was replaced on the Kabul throne; and the policy of intervention in Afghan affairs was suspended for nearly forty years.

It has been said that the declared object of this policy

Approach towards Afghanistan of Russia and England.

had been to maintain the independence and integrity of Afghanistan, to secure the friendly alliance of its ruler, and thus to interpose a great barrier of mountainous country between the expanding power of Russia in Central Asia and the British dominion in India. After 1849, when the annexation of the Punjab had carried the Indian north-western frontier up to the skirts of the Afghan highlands, the corresponding advance of the Russians south-eastward along the Oxus river became of closer interest to the British, particularly when, in 1856, the Persians again attempted to take possession of Herat. Dost Mahommed now became the British ally, but on his death in 1863 the kingdom fell back into civil war, until his son Sher Ali had won his way to undisputed rulership in 1868. In the same year Bokhara became a dependency of Russia. To the British Government an attitude of non-intervention in Afghan affairs appeared in this situation to be no longer possible. A meeting between the Amir Sher Ali and the Viceroy of India (Lord Mayo) at Umballa in 1869 drew nearer the relations between the two governments; the Amir consolidated and began to centralize his power; and the establishment of a strong, friendly, and united Afghanistan became again the keynote of British policy beyond the north-western frontier of India.

Estrangement of Sher Ali from the British.

When, therefore, the conquest of Khiva in 1873 by the Russians, and their gradual approach towards the Amir's northern border, had seriously alarmed Sher Ali, he applied for support to the British; and his disappointment at his failure to obtain distinct pledges of material assistance, and at Great Britain's refusal to endorse all his claims in a dispute with Persia over Seistan, so far estranged him from the British connexion that he began to entertain amicable overtures from the Russian authorities at Tashkend. In 1869 the Russian Government had assured Lord Clarendon that they regarded Afghanistan as completely outside the sphere of their influence; and in 1872 the boundary line of Afghanistan on the north-west had been settled between England and Russia so far eastward as Lake Victoria. Nevertheless the correspondence between Kabul and Tashkend continued, and as the Russians were now extending their dominion over all the region beyond Afghanistan on the north-west, the British Government determined, in 1876, once more to undertake active measures for securing their political ascendancy in that country. But the Amir, whose feelings of resentment had by no means abated, was now leaning toward Russia, though he mainly desired to hold the balance between two equally formidable rivals. The result of overtures made to him from India was that in 1877, when Lord Lytton, acting under direct instructions from Her Majesty's ministry, proposed to Sher Ali a treaty of alliance, Sher Ali showed himself very little disposed to welcome the offer; and upon his refusal to admit a British agent into Afghanistan the negotiations finally broke down.

British expedition, 1878-79.

In the course of the following year (1878) the Russian Government, to counteract the interference of England with their advance upon Constantinople, sent an envoy to Kabul empowered to make a treaty with the Amir. It was immediately notified to him from India that a British mission would be deputed to his capital, but he demurred to receiving it; and when the British envoy was turned back on the Afghan frontier hostilities were proclaimed by the Viceroy in November 1878, and the second Afghan war began. Sir Donald Stewart's force, marching up through Baluchistan by the Bolan Pass, entered Kandahar with little or no resistance; while another army passed through the Khyber Pass, and took up positions at Jalalabad and other places on the direct road to Kabul. Another force under Sir Frederick Roberts marched up to the high passes leading out of Kuram into the interior of Afghanistan, defeated the Amir's troops at the Paiwar Kotal, and seized the Shutargardan Pass which commands a direct route to Kabul through the Logar valley. The Amir Sher Ali fled from his capital into the northern province, where he died at Mazâr-i-Sherif in February 1879. In the course of the next six months there was much desultory skirmishing between the tribes and the British troops, who defeated various attempts to dislodge them from the positions that had been taken up; but the sphere of British military operations was not materially extended. It was seen that the farther they advanced the more difficult would become their eventual retirement; and the problem was to find a successor to Sher Ali who could and would make terms with the British Government.

Treaty of Gandamak.

Cavagnari murdered and the war reopened.

In the meantime Yakub Khan, one of Sher Ali's sons, had announced to Major Cavagnari, the political agent at the headquarters of the British army, that he had succeeded his father at Kabul. The negotiations that followed ended in the conclusion of a treaty in May 1879, by which Yakub Khan was recognized as Amir; certain outlying tracts of Afghanistan were transferred to the British Government; the Amir placed in their hands the entire control of his foreign relations, receiving in return a guarantee against foreign aggression; and the establishment of a British envoy at Kabul was at last conceded. By this convention the complete success of the British political and military operations seemed to have been attained; for whereas Sher Ali had made a treaty of alliance with, and had received an embassy from Russia, his son had now made an exclusive treaty with the British Government, and had agreed that a British envoy should reside permanently at his court. Yet it was just this final concession, the chief and original object of British policy, that proved speedily fatal to the whole settlement. For in September the envoy, Sir Louis Cavagnari, with his staff and escort, was massacred at Kabul, and the entire fabric of a friendly alliance went to pieces. A fresh expedition was instantly despatched across the Shutargardan Pass under Sir Frederick Roberts, who defeated the Afghans at Charasia near Kabul, and entered the city in October. Yakub Khan, who had surrendered, was sent to India; and the British army remained in military occupation of the district round Kabul until in December (1879) its communications with India were interrupted, and its position at the capital placed in serious jeopardy, by a general rising of the tribes. After they had been repulsed and put down, not without some hard fighting, Sir Donald Stewart, who had not quitted Kandahar, brought a force up by Ghazni to Kabul, overcoming some resistance on his way, and assumed the supreme command. Nevertheless the political situation was still embarrassing, for as the whole country beyond the range of British effective military control was masterless, it was undesirable to withdraw the troops before a government could be reconstructed which could stand without foreign support, and with which diplomatic relations of some kind might be arranged. The general position and prospect of political affairs in Afghanistan bore, indeed, an instructive resemblance to the situation just forty years earlier, in 1840, with the important differences that the Punjab and Sinde had since become British, and that communications between Kabul and India were this time secure.

Abdurrahman, the son of the late Amir Sher Ali's elder brother, had fought against Sher Ali in the war for succession to Dost Mahommed, had been driven beyond the

Abdurrahman becomes Amir.

Oxus, and had lived for ten years in exile with the Russians. In March 1880 he came back across the river, and began to establish himself in the northern province of Afghanistan. The Viceroy of India, Lord Lytton, on hearing of his reappearance, instructed the political authorities at Kabul to communicate with him. By skilful negotiations a meeting was arranged, and after pressing in vain for a treaty he was induced to assume charge of the country upon his recognition by the British as Amir, with the understanding that he should have no relations with other foreign powers, and with a formal assurance from the Viceroy of protection from foreign aggression, so long as he should unreservedly follow the advice of the British Government in regard to his external affairs. The province of Kandahar was severed from the Kabul dominion; and the Sirdar Sher Ali Khan, a member of the Bârakzai family, was installed by the British representative as its independent ruler.

Ayub Khan and Abdurrahman.

For the second time in the course of this war a conclusive settlement of Afghan affairs seemed now to have been attained; and again, as in 1879, it was immediately dissolved. In July 1880, a few days after the proclamation of Abdurrahman as Amir at Kabul, came news that Ayub Khan, Sher Ali's younger son, who had been holding Herat since his father's death, had marched upon Kandahar, had utterly defeated at Maiwand a British force that went out from Kandahar to oppose him, and was besieging that city. Sir Frederick Roberts at once set out from Kabul with 10,000 men to its relief, reached Kandahar after a rapid march of 313 miles, attacked and routed Ayub Khan's army on 1st September, and restored British authority in southern Afghanistan. As the British ministry had resolved to evacuate Kandahar, Sher Ali Khan, who saw that he could not stand alone, resigned and withdrew to India, and the Amir Abdurrahman was invited to take possession of the province. But when Ayub Khan, who had meanwhile retreated to Herat, heard that the British forces had retired, early in 1881, to India, he mustered a fresh army and again approached Kandahar. In June the fort of Girisk, on the Helmund, was seized by his adherents; the Amir's troops were defeated some days later in an engagement, and Ayub Khan took possession of Kandahar at the end of July. The Amir Abdurrahman, whose movements had hitherto been slow and uncertain, now acted with vigour and decision. He marched rapidly from Kabul at the head of a force, with which he encountered Ayub Khan under the walls of Kandahar, and routed his army on 22nd September, taking all his guns and equipage. Ayub Khan fled toward Herat, but as the place had meanwhile been occupied by one of the Amir's generals he took refuge in Persia. By this victory Abdurrahman's rulership was established.

In 1884 it was determined to resume the demarcation, by a joint commission of British and Russian officers, of the northern boundary of Afghanistan. The work went on with much difficulty and contention, until in March 1885, when the Amir was at Rawalpindi for a conference with the Viceroy of India, Lord Dufferin, the news came that at Panjdeh, a disputed place on the boundary held by the Afghans, the Russians had attacked and driven out with some loss the Amir's troops. For the moment the consequences seemed likely to be serious; but the affair was arranged diplomatically, and the demarcation proceeded up to a point near the Oxus river, beyond which the Commission were unable to settle an agreement.

Abdurrahman's system of government.

During the ten years following his accession in 1880 Abdurrahman employed himself in extending and consolidating his dominion over the whole country. Some local revolts among the tribes were rigorously suppressed; and two attempts to upset his rulership—the first by Ayub Khan, who entered Afghanistan from Persia, the second and more dangerous one by Ishak Khan, the Amir's cousin, who rebelled against him in Afghan Turkestan—were defeated. By 1891 the Amir had enforced his supreme authority throughout Afghanistan more completely than any of his predecessors. In 1895 the Amir's troops entered Kafiristan, a wild mountainous tract on the north-east, inhabited by a peculiar race that had hitherto defied all efforts to subjugate them—and they have since been gradually reduced to submission. Meanwhile the delimitation of his northern frontier, up to the point where it meets Chinese territory on the east, has been completed and fixed by arrangements between the Governments of Russia and Great Britain; and the eastern border of the Afghan territory, towards India, has also been mapped out and partially laid down, in accordance with a convention between the two Governments. The Amir not only received a large annual subsidy of money from the British Government, but he also obtained considerable supplies of war material; and he moreover availed himself very freely of facilities that were given him for the importation at his own cost of arms through India. With these resources, and with the advantage of an assurance from the British Government that he would be aided against foreign aggression, he was able to establish an absolute military despotism inside his kingdom, by breaking down the power of the warlike tribes which held in check, up to his time, the personal autocracy of the Kabul rulers, and by organizing a regular army well furnished with European rifles and artillery. Taxation of all kinds was heavily increased, and systematically collected. The result was that whereas in former times the forces of an Afghan ruler consisted mainly of a militia, furnished by the chiefs of tribes who held land on condition of military service, and who stoutly resisted any attempt to commute this service for money payment, the Amir had at his command a large standing army, and disposed of a substantial revenue paid direct to his treasury. Abdurrahman executed or exiled all those whose political influence he saw reason to fear, or of whose disaffection he had the slightest suspicion; his administration was severe and his punishments were cruel; but undoubtedly he put down disorder, stopped the petty tyranny of local chiefs, and brought violent crime under some effective control in the districts. Travelling by the high roads is now comparatively safe; although it must be added that the excessive exactions of dues and customs have very seriously damaged the external trade. In short, Abdurrahman's reign produced an important political revolution, or reformation, in Afghanistan, which has risen from the condition of a country distracted by chronic civil wars, under rulers whose authority depended upon their power to hold down or conciliate fierce and semi-independent tribes in the outlying parts of the dominion, to the rank of a formidable military state governed autocratically. How long such a system will outlast the death of its founder in 1901, in the hands of his successor Habibulla, has yet to be seen; for in Asia a centralized administration and a standing army are institutions which depend for their maintenance entirely on the ruler's personal courage and capacity. Up to Abdurrahman's reign the strength of the Afghan nation lay in its warlike character, in the readiness of the tribes to combine for opposing and harassing an invader, and in the local independence of powerful clans or chiefs. Now that the power of the chiefs has been levelled down, and the fighting strength of the tribal groups has been dislocated, the defeat or mutiny of the regular forces may lead to widespread confusion in Afghanistan.

Afghan tribes on Indian frontier.

The extent of the territories subject to the rulers of Afghanistan has varied from time to time with political vicissitudes. Abdurrahman governed a kingdom strictly delimited between the possessions or dependencies of Russia, Persia, and India. It should be mentioned, however, that the geographical boundaries of Afghanistan would include on the eastward all the highlands down to the skirts of the mountains that slope towards the Indian plains; for up to this line, and indeed beyond, the language, habits, and general character of the people are identical. But the frontier laid down in 1894 to mark the eastern limit of the Amir's jurisdiction, cut off from it a zone of tribal territory that had previously been for the most part under the nominal suzerainty of Kabul; though in reality it has always been a debateable land held by unruly and independent tribes. The zone thus interposed between British India and the Afghan rulership may be roughly described as stretching from the southern border of the Chitral state, along the whole north-western frontier of India southwards to the confines of Baluchistan. It is traversed by all the passes that lead out of the Afghan mountains into India; it is occupied at several points by British garrisons or levies in British pay; and it is inhabited by fierce, free, and warlike tribes, whose annals, so far as they have any, belong to the general history of the Afghan people. From time immemorial they have held the valleys and high ranges which overhang the main routes towards the low country; they have taken part in the incessant border wars and the great invasions of India, admitting allegiance to be due from them, as from all Afghans, to the chief ruler of their race, but acknowledging no master. Since 1849 the protection of the Indian borderland has necessitated sending into these hills frequent military expeditions, which have twice entangled the British in serious and prolonged fighting. In 1863 the obstinate resistance made by the tribes to a large British force sent into their country was not overcome without great exertions; and in 1897-98 an insurrection of the tribes in the Swat valley was followed by a general rising of the Afridis, who destroyed a post of British levies in the Khyber Pass, and were only brought to terms after an arduous and harassing campaign. Since 1894, when the Amir of Kabul renounced all claim to jurisdiction over this region, the tribes of the outer hills and valleys on the Indian border have been gradually brought under the superintendence of the British Government by the location of posts inside their country, by enrolling tribal levies, and by other methods for strengthening control. Yet the management of these intractable and fanatic highlanders is still by far the most troublesome of the political and military difficulties that confront the Government along the whole external frontier of the Indian Empire.

RAWLINSON. *England and Russia in the East*, 1875.—Sir H. M. DURAND.—*The First Afghan War*, 1879.—WYLIE'S *Essays on the External Policy of India*, 1875.—Lady BETTY BALFOUR. *Lord Lytton's Indian Administration*, 1899.—ELPHINSTONE. *Account of the Kingdom of Kabul*, 1809.—*Parliamentary Papers*, "Afghanistan."—Lord CURZON. *Problems of the Far East*, 1894. (A. C. L.)

Afiún Kara-Hissar, the popular name of Kara-hissar Sahib, an important trade centre in Asia Minor, in the Brúsa viláyet. Called *Nicopolis* by Leo III. after his victory over the Arabs, in 740, its name was changed by the Seljúk Turks to *Kara-hissar*, "black castle." The town is in the centre of the opium, *afiún*, district, and is connected by railway with Smyrna, Konia, Angora, and Constantinople. Population, 18,000 (Moslems, 13,000; Christians, 5000).

Afragola, a town in the province of Naples, Campania, Italy, 5 miles from Naples. It is on the steam tramway from Naples to Caivano. The principal industries are in straw hats, wine, and the manufacture of wooden articles of all sorts. There is a great annual fair on the second Sunday in May. Population about 20,000.

AFRICA.

I. PHYSICAL GEOGRAPHY.

Form and area.

AFRICA, the largest of the three great southward projections from the main mass of the earth's surface, includes within its remarkably regular outline an area, according to the most recent computations, of 11,280,000 square miles, excluding the islands. Its main structural lines show both the east-to-west direction characteristic, at least in the eastern hemisphere, of the more northern parts of the world, and the north-to-south direction seen in the southern peninsulas. The continent is thus composed of two segments at right angles, the northern running from east to west, the southern from north to south, the subordinate lines corresponding in the main to these two directions.

General structure.

Except quite in the north, the most striking feature in African geology is the great age of the fundamental structures and the absence of signs of recent disturbance of the crust leading to the elevation of folded mountain ranges. Both in the east and west of the meridional portion of the continent a broad zone parallel to the coast-line is composed mainly of ancient crystalline rocks (some of these showing signs of folding), on the flanks of which rocks of palæozoic age still remain in the position in which they were first deposited. In the east a band of gneissose and schistose rocks, supposed to represent the primitive axis of the continent, has been traced at intervals for over half its length. Parallel with this and farther inland run broader belts of ancient rocks, forming in places wide granitic domes. In the west an almost continuous band of crystalline rocks—chiefly schists of varying character—accompanies the whole coast-line of the southern segment, as well as a large part of the southern margin of the western limb. Finally in the centre of the continent, near the meeting-line of the two segments, these ancient rocks seem to occur in lines intermediate between the two main directions. The wide basin between the eastern and western crystalline belts seems to be occupied largely by sedimentary strata, among which horizontally-bedded sandstones figure largely. Owing to the imperfection of the data, and in many cases to the absence of fossils, the age of the strata cannot yet be determined; but apart from recent fluviatile and subaërial deposits, they seem to belong chiefly to the palæozoic or older mesozoic periods. Along the eastern main axis the crystalline rocks are largely overlaid with sheets of volcanic rocks, while numerous volcanoes, some long since extinct, some partially active, have thrust up piles of matter above them.

In Northern Africa the whole geologic structure dates from much more recent times. The most important feature here is the existence of a folded mountain range

North and South Africa.

of comparatively recent date, which runs from east to west parallel to the northern coast. This range—the Atlas—belongs to the European system both in its direction and in its constituent formations. Archæan rocks play quite a subordinate part, while a regular series of stratified formations, from palæozoic to tertiary, most of which have equally experienced the effects of folding, constitute the greater part of the range. Of these the mesozoic—particularly the cretaceous—cover the largest area, while tertiary strata occur chiefly in narrow bands near the coast. The eastern half of North Africa contains large expanses both of tertiary formations and of cretaceous. The extreme south of the continent is marked by the large extent of mesozoic formations (trias, &c.), in addition to older rocks.

Relief.

The mean elevation of Africa has been variously estimated at from 1962 feet (Heiderich) to 2133 (Wagner), and may thus be considered to approximate closely to 2000 feet, which is roughly the elevation of both North and South America, but is considerably less than that of Asia (3117 feet). In contrast with the other continents it is marked by the comparatively small area both of very high and of very low ground, lowlands under 600 feet occupying an unusually small part of the surface; while not only are the highest elevations inferior to those of Asia and South America, but the area of land, over 10,000 feet, is also quite insignificant, being represented almost entirely by individual peaks and mountain ranges. Moderately elevated tablelands are thus the characteristic feature of the continent, though the surface of these is broken by higher peaks and ridges. As a general rule, the greater elevations lie to the east and south, while a progressive diminution in altitude towards the west and north is observable. Apart from the lowlands and the Atlas range, the continent may be divided into two regions of higher and lower plateaux, the dividing line (somewhat concave to the north-west) running from the middle of the Red Sea to about 6° S. on the west coast. We thus obtain the following four main divisions of the continent:—(1) The coastal plains—often fringed seawards by mangrove swamps—never stretching far from the coast, except on the lower courses of streams. Recent alluvial flats are found chiefly in the delta of the more important rivers. Elsewhere the coast lowlands merely form the lowest steps of the system of terraces which constitutes the ascent to the inner plateaux. (2) The Atlas range, which, orographically as geologically, is distinct from the rest of the continent, being unconnected with any other area of high ground, but divided off on the south by a depressed area in places below sea-level. (3) The high southern and eastern plateaux, rarely falling below a height of 2000 feet, and having a mean elevation of about 3500. (4) The north and west African plains, bordered and traversed by bands of higher ground, but generally below 2000 feet.

Higher plateaux.

The two last divisions may be again subdivided. Thus the high plateaux include:—(*a*) The South African plateau as far as about 12° S., bounded on all sides by bands of high ground which fall steeply to the coasts. On this account South Africa has a general resemblance to an inverted saucer. The bounding ridges belong, as a rule, to the crystalline axes of the continent, but in the south-east, where they attain their maximum elevation in the Drakensberg range, the ancient rocks are overlaid by extensive beds of permian and trias. Quite in the south the plateau rim is formed by three parallel steps with level ground between them. In the north the interior basin is demarcated merely by a strip of plateau somewhat more elevated than the rest of the surface. The South African plateau is connected towards the north-east with (*b*) the East African plateau, with probably a slightly greater average elevation, and marked by some distinct features. It is formed by a widening out of the eastern axis of high ground, which becomes subdivided into a number of zones running north and south and consisting in turn of ranges, tablelands, and depressions. A wide area of granite and gneiss runs down the centre, forming in part a rolling plain, while the more elevated ridges are composed chiefly of schists, quartzites, and stratified rocks. The most striking feature is the existence of two great lines of depression, due largely to the subsidence of whole segments of the earth's crust, the lowest parts of which are occupied by vast lakes. Towards the south the two lines converge and we find only one great valley (occupied by Lake Nyasa), the southern part of which is less distinctly due to rifting and subsidence than the rest of the system. Farther north the western depression, sometimes known as the Central African trough, is occupied for more than half its length by water, forming the four lakes of Tanganyika, Kivu, Albert Edward, and Albert, the first-named over 400 miles long and the longest fresh-water lake in the world. Associated with these great valleys are a number of volcanic peaks, the greatest of which occur on a meridional line east of the eastern trough. The eastern depression, known as the East African trough or rift-valley, contains much smaller lakes, many of them brackish and without outlet, the only one comparable to those of the western trough being Lake Rudolf, or Basso Norok. Towards the northern end are Kilimanjaro—with its two peaks Kibo and Mawenzi, the former (according to Dr. Hans Meyer's latest measurement) 19,430 feet, and probably the culminating point of the whole continent—and Kenya (17,180 feet). Hardly less important is the Ruwenzori range (probably over 18,000 feet), which lies east of the western trough. Other volcanic peaks rise from the floor of the valleys, Kirunga, north of Lake Kivu, being still partially active. (*c*) The third division of the higher region of Africa is formed by the Abyssinian highlands, a rugged mass of mountains forming the largest continuous area of its altitude in the whole continent, little of its surface falling below 5000 feet, while the summits reach heights of 15,000 to 16,000 feet. This block of country lies just off the line of the great East African trough, the northern continuation of which passes along its eastern escarpment as it runs up to join the Red Sea. There is, however, in the centre a circular basin occupied by Lake Tsana. The basis of the region is a mass of ancient crystalline rocks which have been furrowed by deep valleys under the influence of denudation. They are surmounted, especially towards the south, by a large area of newer volcanic rocks, which have once covered the surface in continuous sheets, while the north-western margin is overlaid by sedimentary strata of Jurassic age.

Lower plateaux.

The lower north-western half of Africa, though the greater part of its area is below 2000 feet, is traversed by bands of higher ground which run off from the higher lands to the south. Both in the east and west the bordering highlands are continued as strips of plateau parallel to the coast, the Abyssinian mountains being continued northwards along the Red Sea coast by a series of ridges reaching in places a height of 7000 feet. In the west the zone of high land is broader but somewhat lower. The most mountainous districts lie inland from the head of the Gulf of Guinea (Adamawa, &c.), where heights of 6000 to 8000 feet are reached. Exactly at the head of the gulf the great peak of the Cameroon, on a line of volcanic action continued by the islands to the south-west, has a height, according to the measurements of Dr. Preuss, of 13,370 feet, while Clarence Peak, in the first of the line of islands, rises to over 9000. Towards the extreme west the Futa Jallon highlands form an important diverging point of rivers, but beyond this, as far as the Atlas chain, the elevated rim of the continent is almost wanting. The intervening space between the east and west coast highlands is divided into separate basins by other bands of high ground, one of which runs nearly centrally through North Africa in a line corresponding roughly with the curved axis of the continent as a whole. The best marked of the basins so formed occupies a circular area in West Africa bisected by the equator, once probably the site of an inland sea and now largely covered by recent allnvium.

The following table gives the approximate altitudes of the most important features of the continent :-

TABLE OF ALTITUDES.

MOUNTAINS—	FEET.	LAKES (*continued*)—	FEET.
Aiashi (Atlas)	14,000[1]	Kivu	4900
Simen Mountains, Abyssinia	15,200[1]	Tanganyika	2670
Elgon	14,200	Nyasa	1700
Settima	13,390	Mweru	2953
Kenya	17,180	Bangweulu	3700
Kilimanjaro	19,430	Ngami	2950
Ruwenzori	18,000[1]	Leopold II.	1100
Rungwe (Nyasa)	10,400	TOWNS, &c.—	
Drakensberg	11,700	Constantine (Algeria)	2165
Markham, Mashonaland	10,000[1]	Timbuktu	800
Cameroon	13,370	Khartum	1263
LAKES—		Addis Abbaba	8000
Chad	780	Eldoma Ravine Sta., Brit. E. Africa	7240
Tsana	5750	Tabora	4130
Rudolf	1250	Zomba	2948
Victoria Nyanza	3800	Bulawayo	4469
Naivasha	6300	Pretoria	4462
Manyara	3300	Bihe	5500
Albert Nyanza	2100	Leopoldville	1115
Albert Edward	3200	Stanley Falls Sta.	1470

River systems.

From the outer margin of the African plateaux a large number of streams run down to the sea with comparatively short courses, while the rivers of the first class flow for long distances on the interior highlands before breaking through the outer ranges. The main drainage of the continent is to the north and west, or towards the basin of the Atlantic Ocean.

Basin of the Atlantic and Mediterranean.

The high lake plateau of East Africa contains the head-waters of the Nile and Congo; the former the longest, the latter the largest river of the continent. The southern branch of the Nile receives its chief supplies from the mountainous region adjoining the Central African trough in the neighbourhood of the equator. Thence streams pour east to the Victoria Nyanza, the largest African lake, and west and north to the Albert Edward and Albert Nyanzas, to the latter of which the effluents of the other two lakes add their waters. Issuing from it the Nile flows north, and between 7° and 10° N. traverses a vast marshy level, during which its course is liable to blocking by floating vegetation. After receiving the Bahr-el-Ghazal from the west and the Sobat, Blue (more correctly, Black) Nile and Atbara from the Abyssinian highlands, it crosses the great desert and enters the Mediterranean by a vast delta. The most remote head-stream of the Congo is the Chambezi, which flows south-west into the marshy Lake Bangweulu, afterwards turning north through Lake Mweru and descending to the forest-clad basin of west equatorial Africa. Traversing this in a majestic northward curve and receiving vast supplies of water from many great tributaries, it finally turns south-west and cuts a way to the Atlantic Ocean through the western highlands. North of the Congo basin and separated from it by a broad undulation of the surface is the interior basin of Lake Chad—a flat-shored lake filled principally by the Shari coming from the south-east. West of this is the basin of the Niger, the third river of Africa, which, though flowing to the Atlantic, has its principal source in the far west, and reverses the direction of flow exhibited by the Nile and Congo. An important branch, however—the Benue—comes from the south-east. These four river-basins occupy the greater part of the lower plateaux of North and West Africa, the remainder consisting of arid regions watered only by intermittent streams which do not reach the sea. Of the remaining rivers of the Atlantic basin the Orange, in the extreme south, brings the drainage from the Drakensberg on the opposite side of the continent, while the Kunene, Kwanza, Ogowe, and Sanaga drain the west coast highlands of the southern limb; the Volta, Komoe, Bandama, Gambia, and Senegal those of the western limb.

Basin of the Indian Ocean.

Of the rivers flowing to the Indian Ocean the only one draining any large part of the interior plateaux is the Zambezi, the western branches of which come from the neighbourhood of the west coast. Recent explorations have shown that the most remote head-stream is the Liba, which, rising midway across the continent, flows west and south before assuming the eastward direction of the lower river. All the largest tributaries, including the Shiré, the outflow of Lake Nyasa, flow down the southern slopes of the band of high ground which stretches across the continent in 10° to 12° S. In the south-west the Zambezi system interlaces with that of the Taukhe (or Tioghe), from which it at times receives surplus water. The rest of the water of the Taukhe is lost in a system of swamps and saltpans which formerly centred in Lake Ngami, now dried up. Farther south the Limpopo drains a portion of the interior plateau but breaks through the bounding highlands on the side of the continent nearest its source. The Rovuma, Rufiji, Tana, Juba, and Webi Shebeli principally drain the outer slopes of the East African highlands, the last-named losing itself in the sands in close proximity to the sea. Lastly, between the basins of the Atlantic and Indian Oceans, there is an area of inland drainage along the centre of the East African plateau, directed chiefly into the lakes in the great rift-valley. The largest river is the Omo, which, fed by the rains of the Abyssinian highlands, carries down a large body of water into Lake Rudolf.

Areas of drainage systems.

The latest calculation of the areas of African drainage systems, made by Dr A. Bludau (*Petermanns Mitteilungen*, 43, 1897, pp. 184-8) gives the following general results :—

Basin of the Atlantic	4,070,000	sq. miles.
Do. Mediterranean	1,680,000	"
Do. Indian Ocean	2,086,000	"
Inland drainage area	3,452,000	"

The areas of individual river-basins are :—

Congo	1,425,000	sq. miles.
Nile	1,082,000	"
Niger	808,000[2]	"
Zambezi	513,500	"
Lake Chad	394,000	"
Orange	370,500[2]	"
Do. (actual drainage area)	172,500	"

The area of the Congo basin is greater than that of any other river except the Amazon, while the African inland drainage area is greater than that of any continent but Asia, in which the same area is 4,900,000 sq. miles.

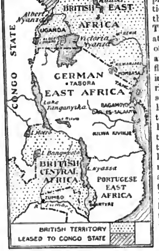
Lakes.

The principal African lakes have been alluded to in the description of the East African plateau, but some of the phenomena connected with them may be spoken of more particularly here. As a rule the lakes which occupy portions of the great rift-valleys have steep sides and are very deep. This is the case with the two largest of the type, Tanganyika and Nyasa, the latter of which was found in 1899 to have a depth of 430 fathoms. Others, however, are shallow, and hardly reach the steep sides of the valleys in the dry season. Such are Lake Rukwa, in a subsidiary depression north of Lake Nyasa, and Eiassi and Manyara, in the system of the eastern rift-valley. Lakes of the broad type, such as the Victoria Nyanza, are probably of intermediate depth. Apart from the seasonal variations of level, most of the lakes show periodic fluctuations, while some have supposed that a progressive desiccation of the whole region is traceable, tending to the ultimate disappearance of the lakes. Such a drying up has no doubt been in progress during long geologic ages, but is probably of no practical importance at the present time. The periodic fluctuations in the level of Lake Tanganyika are such that its outflow appears to be intermittent. After rising steadily for some years after 1871, a fall seems to have set in about 1879, which before the end of the century had carried the lake back within its natural bed. Within about the same time the neighbouring Lake Rukwa (the level of which seems to be almost identical with that of Tanganyika) has in great part dried up. Others of the East African lakes have, on the contrary, risen in level, Nyasa having been unusually high in 1896 and Rudolf in 1896-98; so that, if the fluctuations are due to variations of rainfall, these do not affect the whole lake region simultaneously in the same direction. In the case of the Victoria Nyanza a variation to the extent of 5 feet has been thought to recur in periods of eighteen to twenty-five years. Since 1896 records of the seasonal variations have been kept at stations north of the lake; the maximum in the year having been so far about 15 inches. They may be accounted for in part by the action of winds. Besides the East African lakes the principal are:—Lake Chad, in the northern area of inland drainage; Bangweulu and Mweru, traversed by the head-stream of the Congo; and Leopold II. and Mantumba, within the great bend of that river. All, except possibly Mweru, are more or less shallow. The altitudes of the African lakes have already been stated.

---

[1] Estimated.

[2] Including waterless tracts naturally belonging to basin.



Sketch Map of the Lake Region of Africa.

Origin of Lakes.

Divergent opinions have been held as to the mode of origin of the Central African lakes, especially Tanganyika, which some geologists have considered to represent an old arm of the sea, dating from a time when the whole central Congo basin was under water; others holding that the lake water has accumulated in a depression caused by subsidence. The former view derives some support from the existence in the lake of organisms of a decidedly marine type, the investigation of which has been the work of Mr J. E. S. Moore. They include a jelly-fish, molluscs, prawns, crabs, &c., and form an isolated group found in no other of the African lakes. M. J. Cornet, a Belgian geologist, has expressed a doubt whether these organisms furnish evidence of a former connexion of Tanganyika with the sea.

Climate.

Lying almost entirely within the tropics, Africa does not show excessive variations of temperature. Great summer heat is experienced in the lower plains of North Africa, removed by the great width of the continent from the influence of the ocean, and here too the contrast between day and night, and between summer and winter, is greatest. Farther south, the heat is to some extent modified by the moisture brought from the ocean, and by the greater elevation of a large part of the surface, especially in East Africa, where the range of temperature is also wider than in the western basin. In the extreme north and south the climate is a warm temperate one. The most important climatic differences are due to variations in the amount of precipitation. The wide heated plains of North Africa, and in a lesser degree a corresponding zone of latitude in the south, have an exceedingly scanty rainfall, the winds which blow over them from the ocean losing part of their moisture as they pass over the outer highlands, and becoming constantly drier owing to the heating effects of the burning soil of the interior; while the scarcity of mountain ranges in the more central parts likewise tends to prevent condensation. In the intertropical zone of summer precipitation, this is greatest when the sun is vertical or soon after. It is therefore greatest of all near the equator, where the sun is twice vertical, and less in the direction of both tropics. The rainfall zones are, however, somewhat deflected from a due west-to-east direction, the drier northern conditions extending southwards along the east coast, and those of the south northwards along the west. Within the equatorial zone certain areas, especially on the shores of the Gulf of Guinea and in the Upper Nile basin, have an intensified rainfall, but this rarely approaches that of the rainiest regions of the world. The rainiest district in all Africa, and (in the present state of knowledge) the second rainiest in the world, is a little west of Mt. Cameroon, where at the Debunja station the following results have been recorded:—

1895	353·01 inches	Mean	372·40 inches.
1896	384·96 ,,		
1897	372·72 ,,		
1898	379·20 ,,		

as compared with a mean of 475 inches at Cherrapunji, in Assam. The two distinct rainy seasons of the equatorial zone, where the sun is vertical at half-yearly intervals, become gradually merged into one in the direction of the tropics, where the sun is overhead but once. The question of a progressive desiccation of the continent has been touched upon in speaking of the lakes.

Climate and Health.

While the climate of the north and south, especially the latter, is eminently healthy, and even the intensely heated Sahara is salubrious by reason of its dryness, the tropical zone as a whole is the most unhealthy portion of the world. This is especially the case in the lower and moister regions, such as the west coast, where malarial fever is very prevalent and deadly; the most unfavourable factors being humidity with absence of climatic variation (daily or seasonal). The higher plateaux, where not only is the average temperature lower, but such variations are more extensive, are more healthy; but even here, with the exception of a few specially favoured localities, Europeans find it difficult to maintain their health permanently. Opinions still differ as to the possibility of the acclimatization of white men in Africa, some holding that acclimatization can only be the result of a gradual process extending through many generations, while others believe that with improved knowledge the diseases of Africa and other tropical countries can be successfully dealt with. (On this subject see article by Dr Sambon in *Geographical Journal*, vol. xii. p. 589.) It is believed by the latter school that the malarial germs are propagated by the agency of mosquitos, and during 1899 the discovery of the particular species to which infection is due in West Africa was claimed to be made by Major Ross. Hopes are entertained that suitable measures may lead to its destruction.

Meteorological Observations.

During the last decade of the 19th century a great impetus was given to the record of meteorological data at stations in Central Africa, and our scanty knowledge with respect to that region has already received important additions. The following tables summarize some of the latest results:—

GOVERNMENT STATION, CAMEROON.[1]
Lat. 4° 2′ N. Long. 9° 42′ E. Alt. 40 feet.
(Average for years 1894-98).

	Atmospheric Pressure. Mean.	Mean Temperature.	Mean daily Range.	Relative Humidity %.		Rainfall. ins.	No. of rainy days.
				7 A.M.	2 P.M.		
		°	°				
January .	29·615	79·9	12·2	95	74	·69	4
February .	·812	79·9	12·4	95	72	2·95	7
March .	·796	79·2	12·8	95	75	6·45	13
April .	·819	79·2	16·1	93	76	8·00	16
May .	·862	76·4	12·4	95	77	11·72	19
June .	·941	76·8	10·3	96	62	21·54	21
July .	·957	74·5	7·9	97	67	23·47	26
August .	·941	74·5	8·6	96	85	36·36	28
September .	·914	75·6	9·9	96	64	19·79	23
October .	·684	76·3	10·6	96	83	14·45	23
November .	·819	78·3	11·2	95	80	6·58	11
December .	·848	79·0	11·3	95	79	2·44	7
Year .	**29·867**	**77·6**	**11·1**	**96**	**78**	**168·46**	**196**

MOMBASA.
Lat. 4° 4′ S. Long. 69° 42′ E. Alt. 60 feet.
(Average for years 1894-95).

	Atmospheric Pressure 9 A.M. Mean.	Mean Temperature.	Mean daily Range.	Relative Humidity 9 A.M.	Rainfall.	No. of rainy days.
	ins.	°	°	%	ins.	
January . .	29·862	60·1	7·7	87	·39	2
February . .	·847	60·9	7·5	61	·71	2
March . . .	·816	82·1	7·7	81	1·89	5
April . . .	·838	61·4	7·0	62	5·01	9
May . . .	·899	80·1	6·9	87	12·58	13
June . . .	·925	76·5	7·1	84	2·60	5
July . . .	·981	77·5	7·8	63	2·73	6
August . .	·980	77·6	7·1	83	1·76	6
September . .	·971	78·5	6·9	84	3·05	8
October . .	·914	79·0	6·7	84	1·92	5
November . .	·885	79·5	6·7	62	6·19	9
December . .	·842	80·1	7·6	83	2·29	3
Year . .	**29·897**	**79·6**	**7·2**	**83**	**43·12**	**73**

The first of these tables gives the climatological phenomena at a station in the humid and equable region of the west coast. The dry season is reduced to a minimum, occurring at the time when the sun is at its greatest southward declination. The relative humidity is high and the temperature shows small seasonal variations. The second table, relating to a station on the east coast, likewise shows small variations of temperature, but a relatively small rainfall, divided chiefly between two distinct rainy seasons. The third, the much greater temperature variations at an inland station, at a considerable altitude and farther removed from the equator. The high rainfall is due to the influence of the mountains; but though no month is really dry, the bulk of the rain falls between December and April. Observations for 1897 at Kibwezi, an inland station in the drier parts of British East Africa (2° 25′ S.), at an elevation of 2990 feet, show a still greater daily range of temperature, the mean for the year being 28·5°. The mean temperature for the year was 72·5°, and the rainfall (occurring chiefly in two rainy seasons, separated by a short relatively dry interval) 21·51 inches. At Machakos, a station on the higher plateau (5400 feet), the mean temperature for 1894 was 66·2 (highest month 70·2, lowest 81·4), while a four years' average of the rainfall gives 30·98 inches.

LAUDERDALE, MT. MLANJI, NYASALAND.
Lat. 16° 2′ S. Long. 35° 36′ E. Alt. 2850 feet.
(Average for years 1894-98).

	Mean Temperature.	Mean daily Range.	Relative Humidity %.		Rainfall.	No. of rainy days.
			6 A.M.	2 P.M. (1895-8).		
	°	°			ins.	
January . .	72·6	13·8	90	61	21·04	26
February . .	72·5	16·9	89	82	20·98	25
March . . .	71·9	13·9	93	83	12·60	24
April . . .	69·5	13·4	90	79	15·40	21
May . . .	66·2	14·9	87	74	5·01	13
June . . .	83·2	13·4	61	68	4·34	13
July . . .	62·8	15·5	86	69	3·25	10
August . .	84·7	18·6	86	74	2·59	7
September . .	71·1	21·5	74	55	2·98	6
October . .	74·5	24·9	74	54	6·05	6
November . .	76·9	22·2	64	56	6·39	11
December . .	73·6	16·2	92	80	16·65	22
Year . .	**69·9**	**16·9**	**66**	**71**	**116·48**	**184**

Flora.

The vegetation of Africa follows very closely the distribution of heat and moisture. The northern and southern temperate zones have a flora distinct from that of the continent generally, the north corresponding with south Europe in this respect. The zones of minimum rainfall have a very scanty flora, consisting of plants specialized to resist the great dryness. The more humid regions have a richer vegetation—dense forest where the rainfall is greatest and variations of temperature least, conditions found chiefly on the tropical coasts and in the west African equatorial basin; and savanna interspersed with trees on the greater part of the plateaux, passing as the desert regions are approached into a scrub vegetation consisting of thorny acacias, &c. Forests also occur on the humid slopes of mountain ranges up to a certain elevation. The dense forests of West Africa contain, in addition to a great variety of dicotyledonous trees, two palms, the *Elaeis Guineensis* and *Raphia vinifera*, not found, generally speaking, in the savanna regions. In the latter, the most characteristic trees are the baobab (*Adansonia digitata*), Hyphaene palm, and Euphorbias. The higher mountains have a special flora showing close agreement over wide intervals of space, as well as affinities with the mountain flora of the Eastern Mediterranean, the Himalayas, and Indo-China (*cf.* A. Engler, *Ueber die Hochgebirgsflora des tropischen Afrika*, 1892).

Fauna.

The fauna again shows the effect of the characteristics of the vegetation. The open savannas are the home of large ungulates, especially antelopes, the giraffe (peculiar to Africa), and four species of rhinoceros; and of carnivores, such as the lion, leopard, hyaena, &c. The elephant (though its range has become restricted through the attacks of hunters) is found both in the savannas and forest regions, the latter being poor in large game, though the special *habitat* of the chimpanzee and gorilla. The camel—as a domestic animal—is especially characteristic of the northern deserts and steppes, while the ostrich thrives in most of the drier regions. The rivers in the tropical zone abound with hippopotami and crocodiles, the former entirely confined to Africa. The vast herds of game, formerly so characteristic of many parts of Africa, have much diminished with the increase of intercourse with the interior. Game reserves have, however, been established in South Africa, British Central Africa, British East Africa (2), Somaliland, &c., while measures for the protection of wild animals were laid down in an international convention signed in May 1900.

Of practical questions relating to the African fauna, one of the most important is that of the domestication of the African elephant. Although rarely used in modern times in any of the various ways in which the Indian species is made of service to man, it is known that the African species was tamed in ancient times. A successful experiment in this direction has lately been made in French Congo, where a young African elephant has been used at the Fernan Vaz mission for purposes of transport, while out of eight captured in Cameroon in 1900, three have been successfully tamed. The employment of Indian elephants in East Africa was tried without much success, both by the Belgian expedition of 1879 under Captain Carter and by Count von Götzen in 1893. It is among the lowest subdivisions of the animal kingdom that the species that most injuriously affect the settlement of Africa occur. The devastation caused by locusts need not be dwelt upon, while the question of the spread of malaria by means of mosquitos has already been referred to. Hardly less detrimental by reason of the fatal effects of its bite on most domestic animals is the tsetse fly, an insect fortunately confined to Africa. Researches are being made with a view to discovering the way in which the poison acts, but though it has been proved that the blood of infected animals contains a hæmatozoon closely allied to the *Trypanosoma* present in the Surra disease of India, the endeavour to produce immunity by inoculation has so far failed, nor have any means of alleviating the disease been discovered (cf. *Proc. Roy. Soc.* vol. lxiv.).

---

[1] This table is based on observations recorded in the *Mitteilungen aus den Deutschen Schutzgebieten*; the two following on those published by the British Association Committee.

EXPLORATION.

The last quarter of the 19th century saw the almost entire completion of the broad outlines of African geography. This period has been in the main one of filling in of detail, the wide blank space which previously occupied the centre of the continent on our maps having practically disappeared in 1877. A very brief recapitulation of the earlier stages of African exploration may be given before speaking of this later period.

Earlier Periods.

After the Portuguese voyages to the East had in the 15th century made known the whole coast-line of the continent, a certain amount of progress towards a knowledge of the interior, principally in Angola and the region of the Zambezi, was made. But with the decline of Portuguese power at the end of the 16th century a period of stagnation ensued, broken only by Jesuit and Capuchin missionary enterprise in Abyssinia and Angola, and by French and English trading adventure in Senegambia. The first great advance was due to the action of the African Association (founded 1788), whose agents (Mungo Park amongst them) made known the geography of the Niger region and of various parts of Northern Africa. About 1850 began the great series of journeys, which in the south, east, and north first shed certain light on the geography of the inner regions of the continent—the discovery of the course of the Zambezi by Dr Livingstone; of the great lakes of Eastern Africa and the source of the Nile, by Burton, Speke, Grant, and Baker; and the researches of Dr Barth in the Central Sudan, being the principal results. Dr Livingstone's last great journey, commenced in 1866, began to lift the veil from the western half of the equatorial regions, but, though leading to the discovery of an entirely new river system west of Lake Tanganyika, it was brought to a close by the traveller's death (1873) before the uncertainties which attached to this new river system were cleared up. With Livingstone's death, and the universal interest aroused by the story of his labours, the latest period of African exploration may be said to have begun.

Latest Period. 1873-1900. Cameron and Stanley.

In immediate connexion with Livingstone's work was the expedition of Lieutenant Cameron, who early in 1873 left Zanzibar with the object of supporting the great explorer and carrying on independent geographical work. After learning of the death of Dr Livingstone, which occurred on 1st May[1] of that year, Cameron continued his way to Lake Tanganyika by a new route, and afterwards effected the circumnavigation of the greater part of the lake, discovering its outlet towards the Congo on the west. He then proceeded to Nyangwe, the Arab trading post on the Lualaba or Upper Congo, which had been Livingstone's farthest point on the great river; but the difficulties in the way of a further exploration of its course proving insurmountable, Cameron turned south-west through an entirely unknown region, and made his way across the southern Congo basin to Benguela on the west coast. From his view of the Lualaba, which had been at first thought by Livingstone to belong to the Nile basin, Cameron concluded that it could be nothing else than the upper course of the Congo. Meanwhile Mr H. M. Stanley, who had become famous for his relief of Dr Livingstone in 1871, started again for East Africa as correspondent of the *Daily Telegraph* and *New York Herald* to attempt the solution of the chief remaining problems of Central African geography. His first task was the thorough examination of the Victoria Nyanza, which had been held by some to consist of several independent lakes, and which he reached by a new, almost direct, route from Bagamoyo to its southern point. After circumnavigating the lake and thus proving the general accuracy of its delineation by its discoverer, Captain Speke, Stanley turned west to survey the Albert Nyanza, reaching what he supposed to be a bay of that lake, situated under the equator, but which subsequently proved to belong to an independent piece of water. Compelled to desist from further attempts in this direction, Stanley turned south for Ujiji on Lake Tanganyika, which lake he circumnavigated, and then went west to attack the problem of the termination of the Lualaba. He, too, encountered immense difficulties in the attempt to penetrate the trackless forests of the equatorial basin, but, building a fleet of canoes, succeeded in tracing the river round its great northern bend, until after a journey of 1600 miles he finally reached the known part of the Congo, near the west coast. In this great journey he had to contend not only with natural difficulties, such as the furious cataracts by which the Congo is broken, but with the opposition of warlike cannibal tribes, through whose territory he had constantly to fight his way. The result was to bring to light a river system of hitherto unsuspected magnitude, the Congo proving to be one of the principal rivers of the globe not only in respect of volume and size of basin, but also of length of course, in which respect it is second only to the Nile among African rivers.

West Equatorial Africa.

This great achievement helped still further to stimulate a general interest in Equatorial Africa, which had already had its outcome, since Livingstone's death, in movements destined to lead to important results. In 1873 the German African Society was founded, and this body set itself the task of exploring the interior of Angola and other districts of West Africa. The success attained hardly came up to expectations, but in 1878 Dr Paul Pogge succeeded in reaching the town of the negro potentate, the Muata Yanvo. In that year King Leopold of Belgium summoned to Brussels an international conference to take measures for the systematic opening up of the continent. The outcome was the inauguration of the International African Association with its headquarters in Brussels, while committees were formed in the various European countries, the German society being reconstituted, and continuing to do good work in the southern Congo basin. On the Congo itself Mr Stanley inaugurated a great undertaking on behalf of King Leopold, which ended in the establishment of the Free State of the Congo in the basin of that river, and the exploration of its various tributary streams. Meanwhile the French had already been exploring the interior of their colony of the Gabun, the Ogowe having been explored in 1875 and 1876 by Marche and De Compiègne, and from 1875 by Pierre S. de Brazza, who, reaching the upper basin of that river, made his way across the watershed to the Congo in 1880. The whole region between the Gabun and the Congo was in time explored by French officials, among whom J. de Brazza, brother of Pierre, was one of the first to penetrate to the far north (1885). South of the Congo the Portuguese were likewise active, a great expedition being sent out in 1877 under Pinto, Capello, and Ivens, for the exploration of the interior of Angola. The first-named made his way by the head-streams of the Kubango to the Upper Zambezi, which he descended to the Victoria Falls, thence proceeding south-east to Pretoria and Durban. Capello and Ivens, after crossing the Upper Kwanza, confined their attention to the south-west Congo basin, where they disproved the existence of Lake Aquilunda, which had figured on the maps of that region since the 16th century. Farther south, in the region of the Kunene and Ovampo, good work was done in 1879 and following years by a French missionary, Père Duparquet. Following the example set by Dr Pogge, the Germans Schütt and Buchner added to the knowledge of the Muata Yanvo's empire, while Von Mechow explored the Kwango to about 5° south. The most important results were, however, obtained by Pogge and Wissmann, who passed through previously unknown regions beyond Muata Yanvo's kingdom, and reached the Upper Congo at Nyangwe, whence Wissmann made his way to the east coast. In 1884 Mr Arnot, who had reached Benguela from Natal by a route roughly the reverse of Pinto's, started west and made his way along the Zambezi-Congo watershed to Garenganze or Katanga. In 1884-85 a German expedition under Wissmann solved the most important geographical problem relating to the southern Congo basin by descending the Kasai, the largest southern tributary, which, contrary to expectation, proved to unite with the Kwango and other streams before joining the main river. Further additions to the knowledge of the Congo tributaries were made at the same time by Mr Grenfell, a Baptist missionary, who (accompanied in 1885 by Von François) made several voyages in the steamer *Peace*, especially up the great Ubangi, ultimately proved to be the lower course of the Welle. Another German expedition under Kund and Tappenbeck also made discoveries north of the Lower Kasai.

South Central Africa.

In 1885-87 an Austrian expedition under Dr Lenz crossed Africa from west to east by the Congo and Lakes Tanganyika and Nyasa. Farther south Capello and Ivens in 1884-85 crossed the continent from Mossamedes to the mouth of the Zambezi, breaking new ground *en route*, especially in the borderlands between the Upper

---

[1] 4th, according to the inscription cut by his followers.

Zambezi and Upper Congo. In the southern Zambezi basin and neighbouring districts, the journeys of Holub, Selous, Montagu Kerr, Erskine, and others resulted in more accurate knowledge, especially in Matabeleland and Mashonaland, while Portuguese expeditions under Paiva de Andrada explored the country south of the Lower Zambezi.

East Equatorial Africa.

On Lake Nyasa, where a Scottish mission was established in 1875, Mr E. D. Young in 1876 for the first time reached the north end of the lake, proving that it extended farther than had been supposed. Surveys were also carried out by Mr James Stewart. In 1877 Messrs Elton and Cotterill opened a new route north of the lake to Ugogo. In East, as in West Africa, operations were started by agents of the Belgian Association, but with less success than on the Congo. The first new journey of importance on this side was made (1878-80) on behalf of the British African Exploration Committee by Mr Joseph Thomson, who after the death of his leader, Mr Keith Johnston, made his way from the coast to the north end of Nyasa, thence to Tanganyika, on both sides of which he broke new ground, sighting the north end of Lake Rukwa or Leopold on the east. In 1880-84 a German expedition under Reichard, Böhm, and Kaiser crossed Tanganyika, and penetrated beyond the Upper Congo to Katanga, while in 1882-84 the French Lieutenant Giraud proceeded by the north of Nyasa to Lake Bangweulu, of which he made the first fairly correct map. Between Nyasa and the coast useful work was done about this time by Mr H. E. O'Neill, British consul at Mozambique, as well as by members of the Universities mission, and a little later by Mr J. T. Last. North of the Zanzibar-Tanganyika route a large area of new ground was opened in 1883-84 by Mr Joseph Thomson, who traversed the whole length of the Masai country to Lake Baringo and the Victoria Nyanza, shedding the first clear light on the great East African rift-valley and neighbouring highlands, including Mounts Kenya and Elgon. On the first part of his route he had been preceded by the German Dr G. A. Fischer, who in a second journey broke some new ground to the south and west of the Masai country, traversing for the first time the coast districts east of the Victoria Nyanza (1885-86). A great advance towards the north was made in 1887-89 by the Austrians Teleki and Von Hohnel, who discovered the large Basso Narok, now known as Lake Rudolf, till then only vaguely indicated on the maps as Samburu.

North-East Africa.

Still farther north various attempts were made between 1870 and 1886 to explore the interior of Somaliland, the principal being those of Haggenmacher (1874) and Révoil (1870-84), but they met with only partial success. In 1885, however, the brothers James succeeded in making their way for the first time from Berbera to the Webi Shebeli. In Abyssinia and the Galla countries to the south of it the principal work was done by a band of Italian explorers, among whom the names of Antinori, Antonelli, Bianchi, Cecchi, and Chiarini most deserve mention. Many of the expeditions were unfortunate, but valuable results were obtained by Cecchi and Chiarini, who penetrated the Galla countries to Kaffa (1876-81). In 1881-83 Dr Stecker, and in 1886-87 Dr Traversi, explored the Lake Zuai region; while in 1882 a Dutch traveller, J. M. Schuver, pushed through unknown districts south-west of Abyssinia beyond the Blue Nile. French travellers, among them M. Aubry (1883-85), also made their way to the Galla countries, where a few years later a considerable advance was made by J. Borelli, who reached a point on the Omo farther south than any of his predecessors. On the Upper Nile, where General Gordon and his lieutenants were now waging war against official corruption, and the oppression of the slave traders, the chief geographical work was the survey of the course of the river by Gordon and members of his staff; the examination of the Albert Nyanza by Romolo Gessi and by Colonel Mason; and, somewhat later, various journeys of Emin Pasha to the west of the lake. To the south of Darfur the bounds of knowledge were somewhat extended by Colonel Purdy and by the Greek Dr Potagos, while on and beyond the watershed to the south-west the work of Schweinfurth was continued by the Russian Dr Junker (1876-86), who pushed far down the Welle river, and by Frank Lupton, governor of the Bahr-el-Ghazal province.

North and North-West Africa.

In Northern Africa, embracing the Sahara and western Sudan, the period 1873-85 was not marked by many important expeditions, the attention of explorers being directed to the more central regions. That of Dr G. Nachtigal, which threw valuable light on the region around Lake Chad, had been begun in 1869, though not completed till 1874. Its later stages took the traveller through the almost unknown country of Wadai to the Nile. In 1873-74 the German traveller, Dr G. Rohlfs, undertook his second expedition to the oases north of the Libyan desert, and in 1878-79 penetrated the latter as far as Kufra. A little later (1880-81) a crossing of North Africa from east to west was effected by the Italians Matteucci and Massari, who, starting from Suakin, passed through Wadai, and finally reached the mouth of the Niger. In the Sahara unsuccessful attempts were made to penetrate from Algeria to Timbuktu in 1873-74 by Paul Soleillet, who only reached Insalah, and in 1874-76 by Victor Largeau. In 1876-77 a German traveller, Erwin von Bary, made his way to Rhat and Air, but was assassinated. A French expedition under Colonel Flatters met with a like disastrous fate in 1881. Farther west success was attained in 1880 by a German traveller, Dr Lenz, who starting from Morocco made his way across the Western Sahara, in part by a new route, to Timbuktu. Morocco itself was, a year or two later (1883-84), the scene of important explorations by M. de Foucauld, a French traveller, who, disguised as a Jew, crossed and re-crossed the Atlas, and supplied the first trustworthy information as to the orography of many parts of the chain. In Senegambia, where the political expansion inaugurated by General Faidherbe was continued under Desbordes and Gallieni, additions were gradually made to geographical knowledge. An unsuccessful attempt to reach Timbuktu and Algeria from this side was made in 1878-79 by Soleillet, and it was not till 1887 that the former was reached by Lieutenant Caron, who navigated the Upper Niger in a gunboat. The source of the river had been reached in 1879 by MM. Zweifel and Moustier, agents of a commercial house at Sierra Leone. Behind the Gold Coast, where Kumasi, the capital of Ashanti, had long been the limit of European knowledge, the first step forward was made by Bonnat, who ascending the Volta reached the important mart of Salaga (1875-76). In 1882 Captain Lonsdale went farther, visiting Yendi and Bontuku, while two years later Captain Kirby made his way to Kintampo. On the Middle and Lower Niger no great advance was made during this period; but on its eastern branch, the Benue, good work was done by E. R. Flegel, who charted the river in 1879 during a voyage in the missionary steamer *Henry Venn*, and in 1882-83 penetrated almost to its source during an overland journey in Eastern Adamawa.

Emin Pasha Relief Expedition.

Apart from the French operations in the Sahara, Senegambia, and the Ogowe region, most of the journeys had hitherto been independent of political motives, few territorial claims having yet been made by European nations. From about 1886 onwards exploration was largely connected with the extension of political influence over African territory, inaugurated in 1884 by the annexations of Germany, and regulated by the enactments of the Berlin Conference of 1884-85, and by subsequent international agreements. The future course of exploration can best be followed by taking in turn the work done in the different spheres by European Powers. One great expedition, however, not exclusively connected with any one sphere, must be first spoken of, viz., the Emin Pasha relief expedition under H. M. Stanley, which set out in 1887 by way of the Congo to carry supplies to the governor of the old Egyptian Equatorial province. The route lay up the Aruwimi, the principal tributary of the Congo from the north-east, by which the expedition made its way, encountering immense difficulties, through the great Equatorial forest, the character and extent of which were thus for the first time brought to light. The return was made to the east coast, and resulted in the discovery of the great snowy range of Ruwenzori or Runsoro, and the confirmation of the existence of a third Nile lake discharging its waters into the Albert Nyanza by the Semliki river. A further discovery was that of a large bay, hitherto unsuspected, forming the south-west corner of the Victoria Nyanza.

Cameroon.

In the partition of the continent among European nations, attention was first directed to West Africa, where the activity of the International Association and of France was quickly followed (1884) by the appropriation by Germany of the chief of the previously unclaimed strips of coast. In one of these—Cameroon—the unknown interior had till then been contiguous with the coast-line, but German travellers soon began to throw back its limits. Through the labours of Zintgraff (1887-89), Kund (1887-88), Morgen (1889-90), the river systems of the Sanaga and Nyong were brought to light, and a connexion effected with the Benue and Adamawa in the north. Other travellers—Von Stetten, Kourau, Ramsay, &c.—supplemented their work, while Von Uechtritz and Passarge explored scientifically the region of the Benue (1894). The eastern borders of the territory were first explored in 1897-98 by Von Carnap, and later (1898-99), from the side of the Congo, by Pleyn.

French Congo.

In the adjoining French territory, the Sanga, one of the principal northern tributaries of the Congo, was explored in 1890-92 by Cholet, Ponel, Fourneau, and others, and was reached from the north by Mizon, who drew the first line of communication between the Benue and the Congo (1890-92). In 1890 Paul Crampel, who in the previous year had explored north of the Ogowe, undertook a great expedition from the Ubangi to the Shari, but was attacked and killed, with several of his companions, on the borders of Bagirmi. M. Dybowski, who commanded a supporting expedition, reached the

Gribingi, a principal branch of the Shari. He was followed in 1892-93 by Maistre, who, reaching the Gribingi by a more westerly route, passed westward to the Benue. In 1894 Clozel reached the Wom, a south-western feeder of the Shari, which last was reached in 1896 by Gentil, who for the first time launched a steamer on its waters, and pushed on to Lake Chad, the ultimate objective of the French for many years. Further exploration in the Shari basin was effected in 1898-99 by Béhagle. Farther east, towards the Nile watershed explored first by Junker and others from the north, the pioneers from the south were Belgian officers, who went north from the Congo before the French territorial claims were fully acknowledged. Thus Hanolet reached Dar Runga, south of Wadai, while Nilis and De la Kéthulle made their way (1894) to the borders of Darfur. Subsequently French agents also pushed towards the Nile basin. In 1896-97 Liotard and Cureau reached the western borders of the Bahr-el-Ghazal, while Marchand led a large military expedition through the heart of the province, reaching Fashoda on the Nile early in 1898, and completing the crossing of the continent through Abyssinia to the east coast. Finally, in the west of the French territory, a journey from the Sanga to the coast was accomplished by Fourneau in 1898-99.

Congo State.

Recent exploration in the Congo State has been carried out almost entirely by Belgian officers. After the identity of the Welle with the Ubangi had been finally ascertained, and its course surveyed (1887-88) by Vangele, the upper basin of the river was traversed in all directions by Van Kerkhoven and his subordinates (1891-93), and later by Chaltin and others. Various southern tributaries of the Congo were navigated by Delcommune in 1888-89, particularly the Lukenye and the Boloko or Lomami. In 1890-92 important expeditions traversed the south-east Congo basin by overland routes to Garenganze, under Le Marinel, Delcommune, and Bia, the second of whom reached Tanganyika, and explored the course of the Lukuga. In 1896-97 the two main upper branches of the Congo and the country between them were surveyed by Lieutenants Brasseur and Cerckel, and in 1898 the southern borders of the great Equatorial forest on the eastern verge of the Congo basin were traversed by Lieutenant Glorie.

South-West and South Central Africa.

In German South-West Africa journeys were made, after the annexation of the territory, by Schenck, Schinz, Fleck, Pfeil, François, Dove, and others, who added to the knowledge of the western Kalahari as well as of the districts nearer the coast. In British South Africa Selous and Holub continued their explorations, while in 1895-96 the whole country between the Upper Zambezi and the Kafukwe was explored by Captain (now Major) Gibbons, Mr. Reid, and Captain Bertrand. More recently (1898-1900), Major Gibbons, assisted by Captains Quicke, Hamilton, and others, explored the gorges of the Middle Zambezi, as well as the whole upper basin of the river. The region of Lake Ngami and the Okavango was explored and its geology elucidated in 1896-97 by Dr. Passarge. On the east the boundary with Portuguese territory was surveyed in 1892 by a mixed commission, on which the British representative was Major Leverson. West of Lake Nyasa explorations were made in 1889 and 1890 by Alfred Sharpe, who in the latter year crossed the Loangwa and ascended the Mchinga escarpment; in 1890-91 by Joseph Thomson, who crossed the plateau beyond that escarpment to the neighbourhood of Lake Bangweulu, making a wide circuit to the west and south on the return journey; and more recently by Foa, Weise, Moloney, Codrington, and others. Lake Rukwa, in German territory, north of Nyasa, was visited from the south in 1889 by H. H. Johnston and Kerr Cross; in 1894 by W. H. Nutt, who made his way from the west across the Fipa plateau; and in 1897 by L. A. Wallace, who made the first complete circuit of the lake. The fact of a diminution of its area had already been ascertained by German travellers from the north. Farther west Lake Mweru, Garenganze, and the Luapula were explored in 1890 and 1892 by Alfred Sharpe, while Lake Bangweulu and the Luapula were carefully surveyed in 1895-96 and 1898-99 by Poulett Weatherley. A journey made in 1898 by Mr Campbell, a missionary, from Garenganze to Blantyre by the south of Bangweulu, also deserves mention.

German East Africa.

In the southern districts of German East Africa, the upper basin of the Rufiji was explored in 1886 by Count Pfeil, and the country between that river and the Rovuma in 1893-94 by Von Schele and Ramsay. The hilly districts north of Nyasa have been examined by various travellers, including W. Bornhardt, who in 1896 discovered there considerable deposits of coal. Farther north the parts between the coast and Tanganyika have been surveyed by Prince, Ramsay, and others. Towards the north of the German sphere three important journeys were made across the whole width of the territory within a few years of its final acquisition. In 1891 Emin Pasha, accompanied by Dr Stuhlmann, made his way south of the Victoria Nyanza to the western Nile lakes, visiting for the first time the southern and western shores of Lake Albert Edward. In the same year Dr O. Baumann, who had already done good work in Usambara, near the coast, started on a more extended journey through the region of steppes between Kilimanjaro and the Victoria lake, afterwards visiting the latter and exploring the head-streams of the Kagera, its chief feeder. In the steppe region above alluded to he discovered two new lakes, Manyara and Eiassi, occupying parts of the East African valley system. This region was again traversed in 1893-94 by Count von Gotzen, who passed to the south of Manyara, ascending Mount Gurui in its neighbourhood, and thence continuing his route westwards to Lake Kivu, north of Tanganyika, which, though heard of by Speke over thirty years before, had never yet been visited. He also reached for the first time the line of volcanic peaks north of Kivu, one of which he ascended, afterwards crossing the great Equatorial forest by a new route to the Congo and the west coast. The region of the upper Kagera and Lake Kivu has since been further explored, especially by the Germans Von Trotha, Ramsay, Bethe, Kandt, and Von Beringe, and the Englishmen Grogan and Moore, the first accurate survey of the lake being made by Kandt (1898-99). East of the Victoria Nyanza good work has been done by the zoologist Neumann, and by Von Trotha, Werther, Kaiser, and others. The exploration of Mount Kilimanjaro has been the special work of Dr Hans Meyer.

British East Africa.

In British East Africa the Tana river districts, as far as the slopes of Mount Kenya, were explored in 1889-91 by Pigott, Dundas, Hobley, &c., and the Juba in 1891 by Dundas. The railway survey in 1892 under Macdonald gave an improved basis for the mapping of the country on the line of route, while Captain Lugard traversed the whole territory to Lakes Albert Edward and Albert in 1891-92. Valuable scientific work was done in 1893 by Dr Gregory, who ascended Mount Kenya to a height of 16,000 feet, while the country east and north of the mountain was explored between 1892 and 1896 by Chanler and Von Hohnel, A. H. Neumann, and Kolb, the last-named reaching a point only a few hundred feet below the summit. In 1893-94 Mr Scott Elliot reached Ruwenzori by way of Uganda, returning by Tanganyika and Nyasa, and in 1896 Mr Hobley made the circuit of the great mountain Elgon, north-east of the Victoria Nyanza. During the pacification of Uganda various surveys were executed by British officers. Lake Choga on the Nile between the Victoria and Albert lakes was explored in 1898 by Captain Kirkpatrick, a member of Colonel Macdonald's expedition, while the leader himself advanced north-west from Mount Elgon to the Latuka country, and Captain Austin went north to Lake Rudolf and the Omo. In 1899 Mount Kenya was ascended to its summit by a party including Mr H. J. Mackinder. Lastly, in the region of the Lower Juba, explorations were made in 1895-96 by Mr C. H. Craufurd, and in 1899 by Mr A. C. W. Jenner and Dr W. Radford.

Somali and Galla lands.

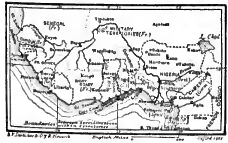
In the peninsula of Somaliland, &c., a period of rapid advance, due chiefly to Italian activity, began about 1890, when Brichetti-Robecchi made a journey along the eastern coast from Obbia to beyond Cape Guardafui. In the following year he went from Mukdishu to Obbia, and thence crossed through Ogaden to Berbera on the Gulf of Aden. In the same year Prince Ruspoli made his first journey southwards from Berbera, while Baudi and Candeo penetrated to Ime on the Upper Wabi, which place was also reached in 1893 by Captain Swayne. In 1892 Bottego and Grixoni left Berbera and made their way past Ime to the Upper Juba, which Bottego explored to its source, both travellers finally making their way *viâ* Logh to the east coast. Prince Ruspoli in 1893 reached Logh from the north, and, proceeding north-west in search of the Omo, discovered the Sagan and Lake Abbaya, but was afterwards killed by an elephant. The next expedition was that of Dr Donaldson Smith, who, starting from Berbera in 1894, explored the head-streams of the Wabi, and made his way to the region of Lakes Abbaya, Stefanie, and Rudolf, ascending the main feeder of the last-named among the mountains to the north. He eventually reached the east coast at Lamu by the east of Lake Rudolf. In 1895 Bottego, accompanied by Sacchi, Vannutelli, and Citerni, left Brava with the purpose of finally solving the problem of the Omo, which some had considered unconnected with Lake Rudolf. Beyond Lake Abbaya he came upon a larger lake to the north (Pagade or Margherita) and pushed west through mountainous country to the Omo, which he succeeded in tracing to Lake Rudolf. After exploring the west shore of that lake the explorers went north-west and discovered the head-streams of the Sobat, afterwards ascending to the Abyssinian highlands, where the leader lost his life during an attack by the natives. An English expedition under H. S. Cavendish (1896-97) followed somewhat in Bottego's steps, but after reaching the south end of Lake Rudolf went south, discovering a new lake in a volcanic region between Rudolf and Baringo. In 1897 the French traveller, De Bonchamps, traversed the southern borderlands of Abyssinia and further explored the head-streams of the Sobat, and about the same time his compatriot, M. Darragon, went south near the chain of lakes ending in Abbaya. Captain Wellby, previously known as a Tibetan explorer, took a somewhat similar route south in 1898-99, but pushed on to Lake Rudolf, and crossed a previously unexplored tract between the lake and the Lower Sobat. In 1899 Blundell, Lovat, &c., traversed the districts south of the Blue Nile, while Donaldson Smith crossed from Berbera to the Nile by Lake Rudolf in 1899-1900.

North Africa.

In North Africa the last decade of the 19th century was not marked by great activity. The Sahara was crossed in 1892 from Lake Chad to Tripoli during the latter part of Monteil's journey (to be spoken of later); but in spite of the persevering efforts of the French to open a route from Algeria to the Sudan success was not attained until 1899, when M. Foureau, who year after year had returned to the task, succeeded in reaching Zinder, afterwards joining Gentil south of Lake Chad and returning by the Congo. In the Algerian Sahara surveys have been executed, partly in connexion with political movements, by Flamand, Germain, Laperrine, &c. In Southern Morocco the Tafilet oasis was reached in 1893 by a new route across the Atlas by W. B. Harris. In the western Sahara, the attempts of the Spaniards and French to penetrate inland met with little success until Adrar was reached (1900) by Blanchet.

French West Africa.

In the western Sudan the same period was one of great activity from the Senegal to the Lower Niger and Lake Chad. In 1887-89 Captain Binger made a great journey through the Mandingo countries to Kong, and thence, after a tour to the north-east as far as Wagadugu, to the coast of Guinea. In 1890-92 Monteil made his way east across the bend of the Niger to Say, and thence to Lake Chad and Tripoli. After the French occupation of Timbuktu surveys in that region were executed by Lieutenants Hourst, Bluzet, &c., and a system of lakes communicating with the Niger was disclosed. After the conquest of Dahomey, Say was reached from that side in 1895 by Decœur and Toutée, both of whom added to our knowledge of the Middle Niger, but more important results were obtained by Hourst, who, leaving Timbuktu in January 1896, descended the river to the sea in spite of the dangerous rapids. The southern parts of the French Sudan have since been traversed by Baud, Alby, Bretonnet, and others, and the interior of the Ivory Coast and parts of Liberia by Marchand, Hostains, Blondiaux, &c. East of the Middle Niger the expeditions of Cazemajou, and of Voulet and Chanoine, have had disastrous results.



Sketch Map of West Africa.

British and German West Africa.

In the British colonies, in addition to the work of various boundary commissions, the Gold Coast *Hinterland* has been penetrated as far as Gambaga and Mosi. The Germans have shown great activity in the adjoining Togoland territory, the interior being explored (1887-93) by Wolf, Von François, Kling, Büttner, and others, while in 1894-95 Drs Gruner and Doering pushed north (simultaneously with the French expedition of Decœur) through Gurma to Say, returning through Borgu, visited shortly before by Captain Lugard on behalf of the British Niger Company. East of the Niger the Benue and districts on each side have been surveyed by Macdonald (1890), and more recently by Clive, Moseley, Hewby, &c.

Trans-continental journeys.

Trans-continental journeys not yet spoken of include those of Versepuy and De Romans, 1895-96 (Uganda, Lake Albert Edward, Equatorial forest, Congo); A. B. Lloyd, a missionary, 1898 (by a somewhat similar route); Foa, 1897 (Nyasaland, Tanganyika, Congo); and Grogan, 1899-1900 (Zambezi, central line of lakes, Nile). By the last-named the whole length of the continent from end to end was for the first time traversed.

Mapping of Africa.

The area of land accurately mapped in Africa is probably less than in any other continent. Although few extensive districts remain of which the general features are not now known, the cartography of by far the greater part of the continent is based merely on route surveys, carried out during more or less rapid journeys, which leave out of consideration the intervening stretches of country. Such route surveys are to a certain extent supplemented by astronomical observations, which may give fairly correct latitudes, but which are rarely to be trusted as determining longitudes with close accuracy.

Triangulation.

The countries in which exact topographical work by means of triangulation has been executed are very few, being limited to Algeria and Tunis; parts of Egypt and the Italian sphere on the Red Sea; the greater part of Cape Colony, and some portions of Natal and British South Africa. Even the results of these surveys have not yet been published in full as maps. In Egypt a survey department has lately been formed, and triangulation is proceeding at a satisfactory rate. The geodetic survey of Cape Colony is now being extended over British South Africa, work having been begun in 1897. It is hoped to carry the triangulation northwards along the 30th meridian to Lake Tanganyika, and thence with German co-operation to the Nile, and eventually down that river to Egypt. In Equatorial Africa the most accurate and most valuable triangulation yet carried out is that of Captain G. E. Smith, R.E., who, while engaged in road-making in British East Africa, executed a survey between the coast and the Victoria Nyanza, extending from Mounts Kilimanjaro and Meru in the south to Kenya and Elgon in the north. In addition to these triangulated areas fairly accurate surveys have been executed along certain lines, such as international boundaries and the tracks of railways. Among the former are the Anglo-German boundaries in East Africa from the coast to Kilimanjaro and on the Nyasa-Tanganyika plateau; the region of the Anglo-Portuguese boundary in South-East Africa; and the Anglo-French boundary behind Sierra Leone; while the most extensive railway survey, apart from the older colonies, is that from the east coast to the Victoria Nyanza.

Maps based on route surveys.

The mapping of other parts of the continent on the basis of route surveys and astronomical observations is of very varying quality. Of large-scale maps of separate European possessions the best have been supplied by the Germans, who have undertaken a complete map of German East Africa on the scale of [illegible].[1] The southern part of Togoland has been mapped by P. Sprigade on the scale of [illegible], and the northern, with adjoining areas, on that of [illegible]. Maps of all the German possessions on the scale of [illegible] are given in Langhans' Colonial Atlas, and the whole area of the Congo State has been shown on the same scale by M. Wauters in the *Mouvement Géographique*. The best maps dealing with the whole continent are those of the French "Service géographique de l'armée," on the scale of [illegible]; and of Habenicht, issued by the German firm of Perthes, on that of [illegible].

Improved methods.

A movement for the better mapping of Africa was set on foot in 1895 by General E. F. Chapman, who brought the subject before the International Geographical Congress, which met that year in London. It was suggested that good results would follow from the mapping by travellers of *areas* rather than routes, and from the accurate determination of certain points in the unsurveyed portions to form a framework for the whole. For the latter object the numerous lines of telegraph now being laid down will afford great facilities, and something has already been done towards obtaining accurate longitudes by such means. The following were determined in this way in 1895-99:—

Point Fixed.	Observers.	Method.	Longitude.
			° ′ ″
Bulawayo	. .	Signals exchanged with Cape Town	Not published
Umtali	Capt. Watherstone	" "	32 40 18 E.
Telegraph clearing 1′ 6″ west of Nkata B., Nyasa	Anglo-German Boundary Commission	" "	34 10 34 E.
Omdurman (Khalifa's ho.)	Col. Talbot, Major Austin, Capt. Lyons	Signals exchanged with Cairo	32 29 42·5 E.
Goz Abu Guma (White Nile)	Col. Talbot, Major Austin	Signals exchanged with Omdurman	32 41 37·5 E.
Wad Medani (Blue Nile)	Lieuts. Gwynn and Jackson	. .	33 31 36·5
Roseires	" "	. .	34 24 51

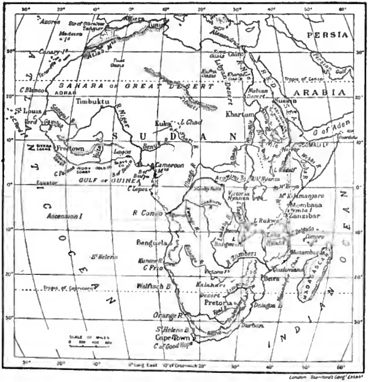
Trade and Communications.

Past isolation.

Apart from the north and south temperate regions the commercial intercourse of Africa with the rest of the world has, for the size of the continent, remained until the present day of quite insignificant proportions. In addition to slaves, which have been furnished by the continent from the earliest times, a certain amount of gold and ivory has long been exported from the tropical regions, but no other product has supplied the material for a flourishing trade with those parts. This was due not so much to the poverty of the country in natural resources, as to special circumstances which likewise caused so large a part of the continent to remain a *terra incognita* down to the 19th century. The principal drawbacks may be summarized as:—(1) Absence of means of communication with the interior; (2) the unhealthiness of the coast lands; (3) the small productive activity of the natives; (4) the effects of the slave trade in discouraging legitimate commerce. Of these the first and last are not necessarily permanent, while the third can be remedied by the introduction of Europeans as supervisors, and possibly of other races as labourers.

---

[1] The first accurate large-scale map of East Africa as a whole was compiled by Mr Ravenstein for the R.G.S. (1882).



London: Stanford's Geog.l Estab.t

SKETCH MAP OF AFRICA.

Resources.

The resources of Africa may be considered under the head of—(1) jungle products; (2) cultivated products; (3) animal products; (4) minerals. Of the first-named the most important are india-rubber and palm-oil, which in tropical Africa supply by far the largest items in the export list. The rubber-producing plants are found throughout the whole tropical belt, and the most important are creepers of the order *Apocynaceæ*, especially various species of *Landolphia* (with which genus *Vahea* is now united). In East Africa *Landolphia kirkii* (Dyer) supplies by far the largest amount, though at least four other species are known. Forms of apparently wider distribution are *L. heudelotii*, which is found in the Bahr-el-Ghazal, and extends right across the continent to Senegambia; and *L.* (formerly *Vahea*) *comorensis*, which, including its variety *L. florida*, has the widest distribution of all the species, occurring in Upper and Lower Guinea, the whole of Central Africa, the east coast, the Comoro Islands and Madagascar. In Lagos and Cameroon much rubber is produced by a large apocynaceous tree, *Kickxia africana*, and in West Africa generally by various species of *Ficus*, some promising species of which are also found in East Africa. The rubber produced is somewhat inferior to that of South America, but this is largely due to careless methods of preparation. The great destruction of vines brought about by native methods of collection has already much reduced the supply in some districts, and renders it precarious everywhere, unless some means are taken to cultivate the rubber-yielding plants. This has already been attempted in Cameroon and elsewhere. Experiments have been made in the introduction of South American rubber plants, but opinions differ as to the prospects of success, as the plants in question seem to demand very definite conditions of soil and climate. For cultivation the *Ficus indica* is said to be a favourable tree, but possibly some endemic species of *Ficus* might prove equally valuable. The second product, palm-oil, is at present derived from a much more limited area, for although the oil palm is found throughout the greater part of West Africa, from 10° N. to 10° S., the great bulk of the export comes from the coast districts at the head of the Gulf of Guinea. A larger supply would certainly be

Jungle products.

available, but with the risk of over-production and lower prices it is doubtful whether an increased export would be profitable. A third valuable product, but one which has not yet been made use of as it might be, is the timber supplied by the forest regions, principally in West Africa. It includes African teak or oak (*Oldfieldia africana*), excellent for shipbuilding; the durable odum of the Gold Coast (*Chlorophora excelsa*); African mahogany (*Khaya senegalensis*); ebony (*Diospyros ebenum*); camwood (*Baphia nitida*); and many other ornamental and dye woods. Some development of the timber industry has lately taken place on the Gold Coast, whence timber was exported in 1898 to the value of £110,000. Valuable timber grows too in South Africa, including the yellow wood (*Podocarpus*), stinkwood (*Ocotea*), sneezewood or Cape ebony (*Euclea*), and ironwood. Other vegetable products of importance are:—Gum arabic, obtained from various species of acacia (especially *A. senegal*), the chief supplies of which are obtained from Senegambia and the steppe regions of North Africa; gum copal, a valuable resin produced by trees of the leguminous order, the best, known as Zanzibar or Mozambique copal, coming from the East African *Trachylobium hornemannianum*, and also found in a fossil state under the soil; kola nuts, produced chiefly in the coast lands of Upper Guinea by a tree of the order *Sterculiaceæ* (*Kola acuminata*); archil or orchilla, a dye-yielding lichen (*Roccella tinctoria* and *triciformis*) growing on trees and rocks in East Africa, the Congo basin, &c.; cork, the bark of the cork oak, which flourishes in Algeria; and alfa, a grass used in paper manufacture (*Machrochloa tenacissima*), growing in great abundance on the dry steppes of Algeria, Tripoli, &c. A product to which attention has been paid of late in Angola is the Almeidina gum or resin, derived from the juice of *Euphorbia tirucalli*.

Cultivated products.

The cultivated products include those of the tropical and warm temperate zones. Of the former, coffee is perhaps the most valuable indigenous plant. It grows wild in many parts, the home of one species being in the Galla countries south of Abyssinia, and of another in Liberia. Cultivation is, however, necessary to ensure the best results, and attention has of late years been given to this in various European colonies. From Angola the export in 1897 reached a value of £175,000, but of this a large proportion was the produce of wild trees. Still more is this the case with the exports from Harrar and Abyssinia, the amount of which passing through the ports of British Somaliland reached a total of £119,000 worth in 1898-99. Encouraging results have been obtained in Nyasaland, which in 1898 exported coffee to the value of over £23,000, although the plantations are still in their infancy. Plantations have also been started in German East Africa, Cameroon, the Congo Free State, &c.

Copra, the produce of the cocoa-nut palm, is supplied chiefly by Zanzibar and neighbouring parts of the east coast. Ground-nuts, produced by the leguminous plant *Arachis hypogæa*, are grown chiefly in West Africa, and the largest export is from Senegal and the Gambia; while Bambarra ground-nuts (*Voandzeia subterranea*) are very generally cultivated from Guinea to Natal. Cloves are extensively grown on Zanzibar and Pemba islands, of which they are the staple products. The chief drawbacks to the industry are the fluctuations of the yield of the trees, and the risk of over-production in good seasons. Cotton, which grows wild in many parts of tropical Africa, is exported in small quantities in the raw state from Angola and elsewhere; but the main export is from Egypt, which comes third among the world's sources of supply of the article. Sugar, which is the staple crop of Mauritius, and in a lesser degree of Réunion, is also produced in Natal, Egypt, and, to a certain extent, in Mozambique. Dates are grown in Tunis and the Saharan oases, especially Tafilet; maize in Egypt, South Africa, and parts of the tropical zone; wheat in Egypt, Algeria, and the higher regions of Abyssinia; rice in Madagascar. Wine is largely exported from Algeria, and in a much smaller quantity from Cape Colony; fruit and vegetables from Algeria. Tobacco is widely grown, on a small scale, but, except perhaps from Algeria, has not yet become an important article of export, though experimental plantations have been tried in various tropical colonies. Cacao and tea have also been tried in some of these, but their cultivation has hardly advanced beyond the experimental stage. The most promising cacao plantations are along the coast of Cameroon, whence the product was exported in 1898 to the value of £15,000. Indigo, though not originally an African product, has become naturalized and grows wild in many parts, while it is also cultivated on a small scale, but is not likely to become an important article of export. The main difficulty in the way of tropical cultivation is the labour question; but some races, such as the Angoni of Nyasaland, have proved good workers, while the introduction of Indian coolies is regarded in some quarters as the solution of the difficulty.

For the study of economic botany, and the development of tropical cultivation, botanical gardens have been established in many of the European possessions, including the Gold Coast, Lagos, Sierra Leone, Old Calabar, Cameroon, British Central Africa, Uganda, and German East Africa.

Animal products.

Of animal products one of the most important at present is ivory, the largest export of which is from the Congo Free State. The diminution in the number of elephants with the opening up of the remoter districts must in time cause a falling-off in this export. Beeswax is obtained from various parts of the interior of West Africa, and from Madagascar. Raw hides are exported in large quantities from South Africa, as are also the wool and hair of the merino sheep and Angora goat. Both hides and wool are also exported from Algeria and Morocco, and hides from Somaliland. Ostrich feathers are produced chiefly by the ostrich farms of Cape Colony, but some are also obtained from the steppes to the north of the Central Sudan. Live stock, principally sheep, is exported from Algeria and cattle from Morocco.

Minerals.

The hitherto exploited minerals of Africa are confined to a few districts only, the resources of the continent in this respect being largely undeveloped. Since the discovery of gold in the Transvaal, particularly in the district known as the Rand (1885), the output has grown enormously, until in 1898 it reached a value of over 15 millions sterling. The gold-yielding formations extend northwards through Mashonaland, which may produce a large amount in the future, and deposits may possibly be discovered in various parts of tropical Africa where ancient schistose rocks occur. In the Galla countries gold has long been an article of native commerce, and on the Gold Coast of European also. Copper is found in the west of Cape Colony, in German South-West Africa, and in the Garenganze or Katanga country in the southern Congo basin, where it has long been exploited by the natives. It also occurs in Morocco, Algeria, Darfur, &c. Iron occurs in Morocco and Algeria (some being exported from the latter), and is widely diffused, and worked by the natives, in the tropical zone. But the deposits are generally not rich, and European iron already competes with the native supply. Coal is worked, principally for home consumption, in Cape Colony, Natal, and Orange River Colony, and has lately been discovered in workable deposits in the German territory north of Lake Nyasa. Diamonds are found in large quantities in a series of beds known as the Kimberley shales, the principal mines being at Kimberley, in the north of Cape Colony. Phosphates are exported to some extent from Algeria. Of other minerals which occur, but are little worked, zinc, lead, and antimony are found in Algeria, lead and manganese in Cape Colony, plumbago in Sierra Leone.

Future development.

Of the natural resources here enumerated those from which a future increase of trade may be expected are probably the plantation products, the cultivation of which is still in an experimental stage. For such a development, however, the solution of the labour problem and the provision of adequate means of transport (to be spoken of later) are indispensable conditions. The country which under a civilized Government would perhaps give the greatest scope for development is Morocco, both the soil and climate of which are exceptionally favourable, while the mineral resources are also considerable. British South Africa, too, contains many valuable minerals besides gold, which will no doubt in time be exploited.

Imports.

The imports from foreign countries into Africa consist chiefly of manufactured goods, varying in character according to the amount of settlement by Europeans. In Algeria and South Africa they include most of the necessaries and luxuries of civilized life, manufactured cotton and woollen goods, especially the former, taking the first place, but various food stuffs, metal goods, coal, and miscellaneous articles being also included. In tropical Africa, and generally where few Europeans have settled, the great bulk of the imports consists as a rule of cotton goods, the only articles for which there is much native demand. This absence of a large demand for European goods is in fact a great obstacle to trade with Central Africa, but with the gradual advance in civilization it may in time be removed. Perhaps the most promising field in this respect is to be found in the populous and comparatively civilized countries of the Central Sudan, reached from the Lower Niger.

The following tables show, so far as statistics are available, the total imports and exports of the various countries for 1898, and also the chief sources of supply of the principal African commodities. Any estimate, based on these figures, either of the total commerce of Africa, or even of the external trade, can only be very vague. No figures are given for inland countries, partly for want of statistics, and partly because the transit trade to and from these already appears under the countries through which it passes. In estimating the total external trade, the special trade only of Zanzibar must be included, as the remainder appears under the countries of the opposite mainland. But in the case of Portuguese East Africa the general trade may be taken, as no figures are given for the adjoining inland countries. A certain amount of local trade between contiguous countries, as, *e.g.*, between Lagos and Dahomey, is of necessity included, but this is possibly not more than enough to balance the absence of figures for certain other countries. The totals thus obtained are:—Imports, £66,828,000; exports, £67,675,000; total, £134,503,000. In 1896 an estimate, probably based on the statistics for 1894-95, gave the grand total as roughly £100,000,000. The increase in about four years would thus be 34 per cent.

Communications.

Native trade routes.

No continent has in the past been so backward in respect of means of communication as Africa, and it was only in the last decade of the 19th century that decided steps were taken to remedy these defects. The African rivers, with the exception of the Middle Congo and its affluents, are generally unfavourable to navigation, and throughout the tropical region almost the sole routes have been native footpaths, admitting the passage of a single file of porters, on whose heads all goods have been carried from place to place. Certain of these native trade routes are, however, much frequented, and lead for hundreds of miles from the coast to the interior. In the desert regions of the north transport is by caravans of camels, and in the south ox-waggons have, until quite recently, supplied the general means of locomotion. On the east side the principal termini of the native trade routes are: Suakin, for the Egyptian Sudan; Massawa, for Abyssinia; Zeila and Berbera, for the Somali and Galla countries; Mombasa and Pangani, for the Masai countries, &c.; Bagamoyo, for the Victoria Nyanza (south), Tanganyika, and Nyasa (north), and for the countries west of Tanganyika; Kilwa, Lindi, Mozambique, and Quilimane for Southern Nyasa and the countries beyond.

AFRICAN TRADE, 1898.

(Values in thousands of pounds sterling.)

Country.	Imports.	Per Cent. from Great Britain.	Exports.	Per Cent. to Great Britain.	Total Trade.
British Colonies, &c.:—					
Egypt	10,755·3	41·1	12,100·1	73·2	22,855·4
Somali Coast	360·2	..	404·7	..	764·9
Zanzibar, special trade	200·0[1]	..	225·0[1]	..	425·0[1]
„ general „	1,555·1	7·8	1,497·9	7·6	3,053·0
British East Africa	296·9	..	72·4	..	369·3
British Central Africa	108·4	..	38·0	..	146·4
Mauritius	2,877·6	18·0	2,913·9	5·7	5,791·5
Natal	5,269·7[2]	69·8	1,363·3[3]	68·2	6,633·0
Cape Colony	16,082·4[4]	68·9	25,918·7[5]	96·1	42,001·1
Niger Coast Protectorate	639·7	79	750·2	66·3	1,389·9
Niger Territory (1898)	160·0	..	405·9	..	565·9
Lagos	908·4	79·7	882·3	45·6	1,790·7
Gold Coast	960·3	75·6	993·0	71·9	1,953·3
Sierra Leone	606·3	84·5	291·0	40·5	897·3
Gambia	246·1	87·1	247·8	21·8	493·9
French Colonies, &c.:—					
French Somali Coast	..	4[6]			
Madagascar	857·1	..	196·4	15·7[6]	1,053·5
Réunion	790·6	·6	761·1	·1	1,551·7
French Congo	190·0	..	178·6	..	368·6
Dahomey	395·8	13·1[7]	298·6	(Lagos, 35·6)[7]	694·4
Ivory Coast	185·9	67·4[7]	186·8	48·0[7]	372·7
French Guinea	360·6	67·7[8]	312·0	77·4[8]	672·6
Senegal	1,318·1	22·8	1,154·3	2·3	2,467·4
Algeria (1897)	11,076·1	2·5	11,829·1	5·0	22,905·2
Tunis	2,140·8	18·9	1,767·9	13·1	3,908·7
German Colonies, &c.:—					
German East Africa	807·3	·3[9]	295·1	2·2[9]	1,102·4
German South-West Africa	287·5	2·0[10]	44·9	79·6	332·4
Cameroons	521·3	16·3	252·1	..	773·4
Togoland	148·5		98·8	..	247·3
Portuguese Colonies:—					
Port. E. Africa, special trade	1,905·2	..	179·7	..	2,084·9
Port. E. Africa, general trade	3,851·9[11]	..	554·5[12]	..	4,406·4
Angola	860·0	24·5	1,135·5	..	1,995·5
Portuguese Guinea					
Italian Colonies:—					
Eritrea					
Italian Somaliland	182·3	..	111·9	..	294·2
Congo Free State	1,007·4	14·0	1,015·9	1·2	2,023·3
Liberia					
Morocco[13]	1,276·0[15]	81·6[15]	1,179·0[14]	96·8[15]	2,455·0[14]
Tripoli	355·4	34·0	401·5	39·1	756·9

ARTICLES OF EXPORT, 1898.

Articles.	Sources of Supply, with Values in Thousands of Pounds Sterling.
Rubber	Angola (887·3); Congo Free State (634·0); Gold Coast (551·7); Lagos (285·4); French Guinea (237·6); Cameroon (94·5).
Palm-oil and kernels.	Niger Coast (705·7); Lagos (459·9); Gold Coast (160·7); Cameroon (110·7).
Gum arabic	Senegal.
Gum copal	Zanzibar (26·7); French Guinea (10·7).
Kola nuts.	Sierra Leone; Gold Coast (35·7).
Copra	Zanzibar (105·1).
Timber	Gold Coast (110·3).
Cork wood	Algeria (239·3).
Bamboos and reeds	Algeria (246·7).
Vegetable horsehair	Algeria (155·5).[16]
Alfa	Tunis (72·7); Tripoli (72·0); Algeria (20·1).[16]

---

[1] Estimated.

[2] Including goods in transit to interior, 938·6.

[3] Including gold from South African States, 40·6.

[4] Including goods in transit, 4581·0.

[5] Including gold from South African States, 15,394·4.

[6] 26·5 and 42·8 respectively in 1896.

[7] Percentages in 1896.

[8] Including imports from and exports to Sierra Leone.

[9] Percentages from and to Zanzibar = 59·2 and 74·2.

[10] Percentage from Cape Colony = 13·8.

[11] Including goods in transit to Transvaal, 1770·1; to Mashonaland, 176·6.

[12] Including exports from Transvaal, 368·9; from Mashonaland, 5·9.

[13] Ports of Tangier, Tetuan, Laraiche, Dar el Baida, Rabat, Mazagan, Saffi, and Mogador.

[14] Including estimate of 250·0 imports and 250·0 exports at Mogador.

[15] Excluding Mogador; from and to Great Britain and Gibraltar.

[16] In 1897.

Articles.	Sources of Supply, with Values in Thousands of Pounds Sterling.
Coffee	Angola (175·1); Harrar, &c., *viâ* Somali Coast (119·2); Brit. Cent. Africa (23·8).
Cacao	Cameroon (15·3).
Sugar	Mauritius (2472·8); Egypt (557·3); Réunion (354·1); Natal (18·2).
Wines	Algeria (5455·4);[1] Cape Colony (15·1).
Cloves	Zanzibar (143·7).
Vanilla	Réunion (275·4); Mauritius (14·0).
Dates	Tunis (48·9).
Ground-nuts	Senegal (Cir. 330·0); Gambia (200·3).
Oil seeds (sesamum)	Mozambique Coast.
Beans	Egypt (347·5).
Almonds	Morocco (63·6).
Table fruit	Algeria (158·8).[1]
Olive oil	Tunis (121·8).
Cotton	Egypt (8659·8).
Tobacco	Algeria (manufactured, 466·1;[1] leaf, 215·7).[1]
Cereals	Algeria (813·7).[1]
Aloe fibre	Mauritius (42·7).
Ivory	Congo Free State (240·5); Zanzibar (112·9); Cameroon (29·3); Somali Coast (24·1); French Congo.
Ostrich feathers	Cape Colony (748·8); Tripoli (70·0).
Wool and hair	Cape Colony (2444·3); Natal (602·0); Algeria (404·3);[1] Morocco (188·1).[2]
Hides and skins	Cape Colony (548·5); Morocco (281·5);[2] Natal (184·9); Algeria (233·8);[1] Somali Coast (157·3).
Sponges	Tripoli (72·0).
Wax	Angola (57·6);[1] Morocco (31·3).[2]
Eggs	Morocco (75·1).[2]
Gold	Transvaal (15,695·1); Gold Coast (63·8).
Diamonds	Cape Colony (4566·9).
Copper ore	Cape Colony (262·8).
Iron ore, &c.	Algeria (180·3).[1]
Phosphates	Algeria (389·1).[1]

On the west side there are fewer important native routes, the dense forests of Guinea proving a barrier to intercourse, while the Central Sudan states have in the past communicated rather with the north across the Sahara than with the shores of the Atlantic. In Senegambia the most frequented routes have long been those up the Senegal and Gambia rivers. In Upper Guinea the chief are those leading north from the Gold Coast, Togoland, and Dahomey ports to the interior markets of Yendi, Sansanne Mangu, and Sansan Hausa on the Niger,[3] and from Lagos to the Niger and Sokoto. South of the equator the principal long-established routes are those from St Paul de Loanda to the Lunda and Baluba countries; from Benguela *viâ* Bihe to Urua and the Upper Zambezi, and from Mossamedes across the Kunene to the Upper Zambezi. In South Africa the ox-waggon routes, now partially superseded, made for Lake Ngami, the Middle Zambezi, and Matabeleland from Walfisch Bay and the middle course of the Orange river, while others traversed the Orange River Colony and Transvaal to the Limpopo and beyond. In the north the principal caravan routes across the Sahara lead from different points in Morocco and Algeria to Timbuktu; from Tripoli to Timbuktu, Kano, and other great marts of the Central Sudan; from Bengazi to Wadai: that from Siut on the Nile through the great oasis and the Libyan desert to Darfur, &c., has been disused of late. Important routes also traverse the Sudan states from west to east, and proceed south to Adamawa from the commercial centres of the Hausa countries.

Recent improvements.

Some of these native routes are now being superseded by the improved communications introduced by Europeans in the utilization of waterways and the construction of roads and railways. Steamers have been conveyed overland in sections and launched on the interior waterways above the obstructions to navigation. On the Upper Nile and Albert Nyanza their introduction was due to Sir S. Baker and General Gordon (1871-76); on the Middle Congo and its affluents to Sir H. M. Stanley and the officials of the Congo Free State, as well as to the Baptist missionaries on the river; and on Lake Nyasa to the supporters of the Scottish mission. The comparative freedom from obstruction between the sea and this lake has led to the introduction on it and on the rivers leading to it of a flotilla of steamers (including gunboats belonging to the British Navy) by which—apart from a short interval broken by rapids on the Shiré—water communication is supplied from the sea to the north end of the lake, beyond which the Stevenson road affords easy communication with Tanganyika.

Steamers.

Here a steamer is being built by a British company, while a small vessel was launched on Lake Mweru in 1900. The Germans have also a steamer on Nyasa, and in 1900 another was launched on Tanganyika, where a British sailing vessel had already plied for some years. A river steamer has been placed by the Germans on the Rufiji. A small vessel was launched on the Victoria Nyanza in 1898 by a British mercantile firm, and a larger Government steamer made its first trip in November 1900. On the Niger and Benue, where navigation is open from the sea for a considerable distance into the interior, steamers have plied for many years, while the French have placed steamers on the navigable portion of the upper river. The middle course of the river is only just navigable for part of the year. A small steamer for the navigation of the Shari and Lake Chad was taken out by the Gentil expedition, by way of the Congo, in 1896-97.

Roads.

Roads suitable for wheeled traffic, even of the most primitive kind, are still few. The first attempt at road-making in Central Africa on a large scale was that of Sir F. Buxton and Mr (afterwards Sir W.) Mackinnon, who completed the first section of a track leading into the interior from Dar-es-Salaam (1879). A still more important undertaking was the road, begun in 1881, from the head of Lake Nyasa to the south end of Tanganyika, constructed mainly at the expense of Mr James Stevenson, which forms a link in the "Lakes route" into the heart of the continent. In British East Africa a road was made from Mombasa to Kibwezi under the auspices of the British East Africa Company, and afterwards continued for the British Government by Captains Sclater and Smith to Port Victoria on the Victoria Nyanza. From Kikuyu it descends to the great rift-valley, on the farther side of which it ascends the Mau Escarpment near the Eldoma ravine. The continuation, 400 miles long, was begun in 1895 and completed in about two years at a cost of some £17,000. In German East Africa the caravan track to Tanganyika has recently been much improved and other roads made, generally with a width of 5 to 8 metres, while transport by means of mule carts has been initiated. In Cameroon a road has been made from Victoria northwards to Buea, and others are contemplated. In Madagascar a road 5 metres broad, macadamized to a width of 3 metres, was under construction in 1900 between Antananarivo and the coast at Andevorante, between which place and Tamatave communication is maintained both by a shore road and by the line of lagoons. Farther north the construction of a road from the capital to Mevatanana, whence water transport is available to Majunga, was begun in 1897.

Railways.

Position in 1890.

Although still occupying a low place among the continents in the matter of railway communication, Africa was during the last decade of the 19th century the scene of an important development in that direction. In 1890 African railways were almost entirely confined to the extreme north and south (Egypt, Algeria, Cape Colony, and Natal); while apart from short lines in Senegal, Angola, and at Lourenço Marques, the rest of the continent was wholly without a railway system. In Egypt the Alexandria and Cairo railway dates from 1855, while in 1877 the lines open reached about 1100 miles, and in 1890, in addition to the lines traversing the delta, the Nile had been ascended to Assiut. In Algeria the construction of an inter-provincial railway was decreed in 1857, but was still incomplete twenty years later, when the total length of the lines open hardly exceeded 300 miles. Before 1890 an extension to Tunis had been opened, while the Atlas had been reached by the lines to Ain Sefra in the west and Biskra in the east. In Senegal the railway from Dakar to St Louis had been commenced and completed during the 'eighties, while the first section of the Senegal-Niger railway, that from Kayes to Bafulabe, was also constructed during the same decade. In Angola a line from Loanda towards the interior, bearing the ambitious title "Royal Trans-African Railway," had been opened for a short distance before 1890. In Cape Colony, where in about 1880 the railways were limited to the neighbourhood of Cape Town, Port Elizabeth, and East London, the next decade saw the completion of the trunk-line from Cape Town to Kimberley, with a junction at De Aar with that from Port Elizabeth, as well as of the lines from Port Elizabeth to Graaf Reinet, and from East London to Burghersdorp. The northern frontier had, however, nowhere been crossed. In Natal, also, the main line had not advanced beyond Ladysmith. In the neighbouring Portuguese territory the line from Lourenço Marques towards the Transvaal, commenced in 1887, had not quite reached the frontier when seized by the Portuguese authorities in 1889. Within the Transvaal the railway to Pretoria was, however, under construction.

Recent developments.

Recent railway development was inaugurated by the scheme for the Congo railway, connecting the navigable portions of the upper and lower river, operations on which had been begun before 1890, but which was not opened throughout until July 1898. A little later the Angola railway was opened as far as Ambaca, while its extension to Malanje has been decided upon. In East Equatorial Africa a beginning was made by the construction, within the German sphere, of a short line from Tanga towards Usambara; but in spite of many schemes for a trunk line to the great lakes, no decided action had yet been taken in 1901, the necessary credits for the expenses of a line from Dar-es-Salaam to Tanganyika, with a branch to the Victoria Nyanza, having been refused. In British East Africa a survey for a railway to the Victoria Nyanza was carried out in 1892, and the first rail laid in 1896. The route adopted, after traversing Kikuyu, drops down to the rift-valley by a steep and difficult descent, afterwards climbing the Mau Escarpment to Port Florence on Kavirondo Bay. In April 1901, 488 miles had been completed out of a total of 582. In French Somaliland a railway is under construction from Jibuti to Harrar, with the object of tapping the trade of Abyssinia. In British Central Africa a scheme has been set on foot for a railway past the rapids of the Shiré. In South Africa the Cape trunk-line has been continued *viâ* Mafeking to Bulawayo, which was reached in 1897, while a line from Beira to Salisbury, commenced in 1891, was completed in 1899. The Natal and Cape railways have been continued north to the Transvaal (the latter traversing the whole length of Orange River Colony), meeting the completed Lourenço Marques railway at Pretoria. Other lines have also been constructed or commenced both in the Transvaal and Orange River Colony. In 1899 a northern extension of the Bulawayo railway, towards the Zambezi, was commenced as a section of a great scheme for a railway from end to end of the continent, passing through German East Africa and Uganda to Cairo; while another step towards the realization of the project was taken in the same year by the completion of the Nile railway to Khartum. Pending a possible extension to the Upper Nile, steam communication by river in that direction was opened by the cutting of the *sudd*, or grass barrier, early in 1900 by Major Peake. Another Egyptian railway which is probably only a question of time is one from Suakin to Berber or Kassala. Farther south a short line has been open for some years at Massawa. In Algeria an extension of the western railway was opened to Jenien-bu-Rezg at the beginning of 1900, while the much-discussed project of a line or lines across the Sahara to Timbuktu and Lake Chad has again come into prominence. In French West Africa the construction of a line from Konakri to the Upper Niger has been commenced, while work on the Senegal-Niger line has been continued. On the Ivory Coast the survey for a proposed railway towards the interior was completed in 1899, and in Dahomey a line from Kotonu to the Niger, by a route passing through Carnotville and Nikki, has been begun. In French Congo, although the need of a line to Brazzaville on Stanley Pool is acknowledged, little progress towards a realization of the project has been made. In the British West African colonies lines have since 1896 been under construction in Sierra Leone, the Gold Coast, and Lagos. In the Congo Free State a short railway to Mayumbe, north of the lower river, is being constructed, and lines are proposed from Stanley Falls to Albert Nyanza and Tanganyika. Finally, in Madagascar, the credits for a line from Tamatave to the capital were voted early in 1900.

---

[1] In 1897.

[2] Exclusive of export from Mogador.

[3] The former trade centres, Kong, Salaga, and Say, have lately lost their importance.

Telegraphs. The telegraphic system of Africa is on the whole older than that of the railways, the newer European possessions having in most cases been provided with telegraph lines before railway projects had been set on foot. In Algeria, Egypt, and Cape Colony the systems date back to the middle of the 19th century, before the end of which the lines had in each country reached some thousands of miles. In tropical Africa the systems of French West Africa, where the line from Dakar to St Louis was begun in 1862, are the most fully developed, lines having been carried from four different points on the coast of Senegal and French Guinea towards the Niger, the main line being prolonged north-west to Timbuktu, and west and south to the coast of Dahomey; while other lines are either open, being constructed, or projected, including one connecting the Ivory Coast with the general system. In French Congo, also, a line connects Brazzaville with the coast at Loango, whence it runs northwards to Libreville. Most of the European colonies and protectorates have lines of more or less length, but the most important is that initiated by Mr Cecil Rhodes, which, starting northwards from the Cape, is destined before long to connect the north and south extremities of the continent. It crosses the Zambezi to Lake Nyasa, beyond which it has already passed the south end of Tanganyika, while from the north the Egyptian lines have been prolonged beyond Khartum to the Upper Nile. A line from the east coast, which will eventually connect with the Cape to Cairo line in Uganda, has been carried through British East Africa in advance of the railway, reaching the Nile at Ripon Falls in February 1900. Considerable progress has been made with a line which will cross the whole width of the Congo Free State to Lake Tanganyika, where it may eventually be connected with the German line from Dar-es-Salaam to the lake.

LITERATURE.—The following is a selection of works relating to Africa as a whole, or large portions of the continent.—HERODOTUS (edited by RAWLINSON). *History.* London, 1880.—MÜLLER. *Geographi Græci Minores.* Paris, 1855-61.—*Idem. Claudii Ptolemæi Geographia.* Paris, 1883.—MANNERT. *Geographie der Griechen und Römer*, vol. x. Leipzig, 1825.—D'AVEZAC. *Description . . . de l'Afrique ancienne.* Paris, 1845.—IBN HAUKAL (10th cent., trans. Slane). "Description de l'Afrique," *Nouv. Journ. Asiat.* 1842.—EDRISI (12th cent., trans. Jaubert). "Géographie," *Rec. de voyages . . . publié par la Soc. de Géogr.* vol. v. Paris, 1836.—ABULFEDA (14th cent., trans. Reinaud and Guyard). *Géographie.* Paris, 1848-83.—LEO AFRICANUS (16th cent., trans. Pory, ed. Robert Brown). *History and Description of Africa.* London, Hakluyt Society, 1896.—KUNSTMANN. *Afrika vor den Entdeckungen der Portugiesen.* Munich, 1853.—BARROS. *Asia, Ira Decada.* Lisbon, 1552 and 1777-78.—MARMOL. *Descripcion General de Africa.* Granada, 1573.—SANUTO. *Geographia dell' Africa.* Venice, 1588.—DAPPER. *Description de l'Afrique.* Amsterdam, 1686.—ESTANCELIN. *Recherches sur les . . . navigateurs Normands en Afrique.* Paris, 1832.—MAJOR. *Life of Prince Henry the Navigator.* London, 1868.—CORDEIRO. *L'Hydrographie Africaine au XVIe Siecle.* Lisbon, 1878.—BRUCKER. *Découvreurs et Missionnaires dans l'Afrique Centrale, au XVIe et XVIIe Siècle.* Lyon, 1878.—D'ANVILLE. *Mémoire concernant les Rivières de l'intérieur de l'Afrique.* Paris, n.d.—*Proceedings of the Association for Promoting the Discovery of the Interior Parts of Africa.* London, 1790-1810.—*Historical and Geographical Sketch of the Discoveries . . . of Europeans in North and West Africa at the Close of the 18th Century.* Edinburgh, 1799.—MURRAY. *Historical Account of Discoveries, &c.* Edinburgh, 1818.—WALCKENAER. *Recherches géographiques sur l'Intérieur de l'Afrique Septentrionale.* Paris, 1821.—M'QUEEN. *Geographical and Commercial View of Northern and Central Africa.* Edinburgh, 1821.—*Idem. Geographical Survey of Africa.* London, 1840.—COOLEY. *Inner Africa Laid Open.* London, 1852.—OLIVER. *Flora of Tropical Africa.* London, 1868.—*General Act of the Conference of Berlin.* London, 1886.—UMLAUFT. *Afrika in kartographischer Darstellung von Herodot bis heute.* Vienna, &c. 1887.—GÜRICH. "Ueberblick über den geologischen Bau des afr. Kontinentes," *Petermanns Mitteilungen.* Gotha, 1887.—RECLUS. *Nouvelle Géographie Universelle*, vols. x. to xiii. 1885-88.—SUPAN. "Ein Jahrhundert der Afrika-Forschung," *Peterm. Mitt.* 1888.—HEIDERICH. "Die mittlere Höhe Afrikas," *Peterm. Mitt.* 1888.—REICHARD. "Das afrikanische Elfenbein und sein Handel," *Deutsche Geogr. Blätter.* Bremen, 1889.—LAVIGERIE. *L'Esclavage Africain.* Paris, 1888.—*Possedimenti e protettorati Europei in Africa.* Rome, 1889 and 1890.—*La Traite des Esclaves en Afrique.* Brussels, 1890.—SIEVERS. *Afrika.* Leipzig, 1891 and 1901.—WHITE. "On the Comparative Value of African Lands," *Scott. Geog. Mag.* 1891.—*Idem. The Development of Africa.* 2nd ed. London, 1892.—ENGLER. *Hochgebirgsflora des tropischen Afrika.* Berlin, 1892.—*Idem.* "Ueber die . . . Ergebnisse der . . . botanischen Forschungen," &c. *Peterm. Mitt.* 1894.—JAEGER. *Die Verwendbarkeit des afrikanischen Elefanten.* Magdeburg, 1892.—ROBERT BROWN. *The Story of Africa and its Explorers.* London, 1892-95.—RAVENSTEIN. "Reports . . . on the Climatology of Africa," *Rep. Brit. Assoc.* 1893-99.—PRÉVILLE. *Les Sociétés Africaines.* Paris, 1894.—FELKIN. "On the Geographical Distribution of Tropical Diseases in Africa," *R. Phys. Soc.* Edinburgh, 1894.—REICHARD. "Zur Frage der Austrocknung Afrikas," *Geogr. Zeitschrift.* 1895.—MURRAY. *How to Live in Tropical Africa.* London, 1895.—FUTTERER. *Afrika in seiner Bedeutung für die Goldproduktion, &c.* Berlin, 1895.—KEANE. *Africa* (in Stanford's Compendium). London, 1895.—DEWÈVRE. "Les Caoutchoucs Africains," *Ann. Soc. Scient. Bruxelles.* 1895.—KELTIE. *The Partition of Africa.* 2nd ed. London, 1895.—HERTSLET. *The Map of Africa by Treaty.* London, 1896.—DARWIN. "Railways in Africa," *Geogr. Journal.* November, 1896.—POSKIN. *L'Afrique Equatoriale, Climatologie, Nosologie, Hygiène.* Brussels, 1897.—DÈCLE. *Three Years in Savage Africa.* London, 1898.—VAN ORTROY. *Conventions Internationales définissant les limites . . . des Possessions, &c.* Brussels, 1898.—JOHNSTON. *A History of the Colonization of Africa by Alien Races.* Cambridge, 1899.—*Trade and Shipping of Africa* (from *Board of Trade Journal*). London, 1899. See also the works of explorers mentioned in the above article.

(E. HE.)

II. ETHNOLOGY.

That Africa has been continuously occupied by two distinct branches of mankind—the *Caucasic* and the *Ethiopic*—from the remotest times, seems evident both from the remains of primitive man which have been found wherever they have been sought, and from the ethnical relations that have prevailed throughout the historic period. The remains—that is, rude and polished flints and other implements dating from the Old and New Stone Ages—have in recent years been brought to light in great abundance in the extreme north and south, and in several intermediate places, under conditions which leave no doubt that the whole area was peopled since the early Pleistocene, if not even the late Pliocene, epoch. Thus, in Egypt Professor Flinders Petrie has collected large quantities of Palæoliths on the limestone Abydos plateau, 1400 feet above the present Nile level, and others embedded in the ancient gravels of the former High Nile, when the main stream still rolled down fifty times its present volume. In the same region of Upper Egypt M. J. de Morgan has identified four stations where primitive man worked his rude weapons, and where Oppert finds indications of a thoroughly established social and political organization in the New Stone Age, some 12,000 years before the new era. In Tunisia M. A. Dumont found flints in abundance under limestone beds deposited by a river which has since disappeared, and declares that the origin of man in Mauritania must be set back to an age which deranges all chronology and confounds the very fables of the mythologies. The same inference is drawn by Sir John Evans from the results of Mr Seton Karr's researches in Somaliland, while the wide range of early man is further attested by the objects recovered by Sir R. Burton in Upper Guinea, and by W. D. Cooch and J. Sanderson in Cape Colony and Natal.

All the works of the Old Stone Age present, wherever found, a striking resemblance in their appearance, form, and method of production, implying that they date from an age when all the inhabitants of Africa were still of one type and stood at the same low stage of culture. They appear to have migrated westwards from Indo-Malaysia, probable cradle of mankind, in two streams, one by the not yet submerged or but partly submerged Indo-African continent, now flooded by the Indian Ocean; the other, by the overland Asiatic route, which was also followed by the large partly extinct and partly surviving Pliocene and Pleistocene mammalian fauna.

In their new homes these two groups, originally of the same generalized proto-human Pleistocene type, gradually became specialized under the influence of the different physical environments—relatively hot and dry in the north, hot and moist in the south. Thus may well have arisen on African soil the two now highly specialized divisions of mankind which share the continent between them, although the process of specialization may have been, and probably was, already in progress before their arrival. It now becomes easy to understand how what are accepted as the highest and the lowest sections of the human family are found occupying conterminous domains since prehistoric times, the southern stream being still represented by the Negro or black populations of Sudan and thence southwards to the extremity of the continent, the northern by the Caucasic or white populations of the Sahara, and thence northwards and westwards into Europe and Asia. We also see how unnecessary it is with a former school of anthropologists to derive the whites from their black neighbours, or, a still more difficult process, the blacks from the whites. Both have been evolved independently in their present respective *habitats*, where they may therefore be regarded as aborigines in the strict sense of the term.

But the two ethnical zones are nowhere separated by any marked mountain barriers except in the eastern (Abyssinian) highlands, or even by great marine or desert spaces, such as would be impassable by primitive man, for we now know that at all events since the early Tertiary epoch the Sahara has been dry, and, till later times, even habitable land, and not, as formerly supposed, a marine basin. Hence there have been constant and continuous overlappings and interminglings all along the ethnical divide, and as the large fauna—elephant, hippopotamus, giraffe, lion, hyena, ostrich—range over the whole continent, so the dark Sudanese peoples have encroached at various points—Tibesti Range, Nile Valley, &c.—on the Caucasic domain, while the Caucasians have to a far larger extent penetrated into the Negro zone, reaching especially on the eastern seaboard to the southern limits of the mainland.

These diverse secular bleeds have resulted in a multitude of transitional forms between the two primeval stocks, presenting a kaleidoscopic picture which has been further complicated by the intrusion of numerous foreign elements—Semitic Himyarites, Phœnicians, and Arabs, Greeks, Romans, Vandals, Malays, Hindus, modern Europeans, and others—generally round the periphery, but in some cases penetrating far into the interior.

But amid all this ethnical confusion the two original groups have in many places preserved their racial purity almost intact, so that a tolerably correct estimate may still be formed of their essential physical characters. The *Hamites*, as the Caucasic aborigines are conventionally called, present striking analogies both with the Asiatic Semites and with the South Europeans, so that by many ethnologists all are regarded as belonging fundamentally to one stock, collectively classed as *Afro-Europeans* or *Mediterraneans*. Thus many of the Mauritanian Hamites (Berbers of Morocco, Algeria, and Tunisia) are of even lighter colour than the Spaniards or Italians, with blue eyes, yellow or brown beard, oval head of the long type, large straight or aquiline nose, perfectly regular features, shapely build, medium height, and altogether exceedingly handsome men. Similar traits occur amongst their southern kinsmen, the *Tuaregs* of the Western Sahara, and even amongst the *Fellahin*, of Egypt, who, however, are generally of swarthier complexion and often startlingly like their *Retu* ancestors, as figured and carved on the old Egyptian monuments. Still darker are the *Herratin*, or "Black Berbers," of the Southern Atlas, and all the eastern Hamites between Egypt and the equator, who betray a varying strain of negro blood in their tumid lips, and especially in their crisp or ringlety and always black hair.

The Hamitic language also, which is of the inflecting order, presents several features in common with the Semitic, on the one hand, and on the other with the old Iberian, still surviving in the Basque of the Western Pyrenees. This Hamitic form of speech, which, like the Semitic and unlike the Aryan, is of an extremely tenacious character, pervades the whole of the African Caucasic domain, where it has been current for countless ages, and had already been reduced to written form by the Egyptians some 5000 or 6000 years before the new era. Letters were also known in remote times to some other members of the Hamitic family, as shown by the not yet deciphered rock inscriptions in the Nile valley above Egypt, and in the peculiar *Tafinagh* script still in restricted use amongst the Mauritanian and Saharan Berbers.

Except in Egypt, where all were merged many millenniums ago in a single despotic monarchy, the Hamitic peoples have always shown a marked tendency towards Democratic institutions. In the tribal system everything is regulated by the public assembly, in which all have a voice, so that the Berber is what he calls himself, *Amazigh* (plural *Imazighen*, the national name), a "freeman," whereas the more theocratic and feudal Semitic community is ruled by a despotic hereditary sheikh. The Berber is also less fanatical, though all have long been Mohammedans, more generous to his womenfolk, and of rather sedentary habits, preferring fixed dwellings and agriculture wherever possible to the tent-life of the nomad Bedouin stock-breeder. Pastoral ways, however, prevail largely amongst the Eastern Hamites—Bejas, Somali, Gallas, Turkanas, Masai—who roam the steppe lands between the Nile and Red Sea and the Mau plateau, which are unfavourable for tillage. Hence it is that the Wahumas, who are of Galla descent, retain their nomad pastoral habits amid the Bantu Negroid populations of East Central Africa.

The negroes themselves, whose physical and mental characters are elsewhere described (Art. NEGRO), form almost everywhere settled agricultural communities. But this is not due to any superiority over the nomad Hamites and Semites, to whom they are greatly inferior in most respects, but to the nature of their environment, which, lying mainly between the tropics, enjoys an abundant rainfall, and is consequently more favourable for agriculture than for pasturage. Hence it is that the inhabitants of the arid south-western steppes (Damara and Namaqua lands) form an exception to the general rule, and are excellent herdsmen, but cultivate very little land. Compared with the Hamites, the negroes are also extremely cruel and superstitious, and with the exception of the mixed negroid populations of Sudan—*Songhay*, *Hausas*, *Baghirmi*, *Kanuri*, *Mabas*, and others now mostly Mohammedans—are still mainly pagans, though Christianity has made some progress amongst the *Waganda* of Lake Victoria, and the Zulus-Xosas, Basutos, and Bechuanas of the extreme south. Ancestor-worship prevails on the eastern, nature-worship on the western seaboard, with interminglings in the interior. This is clearly seen by the distribution of the two chief names of the Deity—*Munkulunkulu*, "Great-grand-Father," and *Nzambi*—of uncertain meaning, but indicative of the forces of nature, variants of which terms occur, the former almost exclusively along the east, the latter along the west side of the continent, while both are intermingled in the central regions.

It is further to be noticed that the two primordial stocks—the white and the black—are found from remote times already divided into several secondary groups, whose obscure inter-relations still offer many difficult problems to the ethnologist. In general such secondary groups are far less aberrant from the normal type, and more easily accounted for, in the Caucasic than in the negro domain. Amongst the Hamites the chief divergences are represented by the *Nubians* of the Nile valley above Egypt, who are usually regarded as Hamites with a black strain, but are on the contrary true negroes with a Hamitic strain (Art. NUBIA); the *Tibbus* of the Eastern

Sahara, treated as negroes with a Hamitic strain, but undoubtedly true Hamites, merging gradually southwards in the black populations of the Chad basin (Art. Tibbus); the *Fulahs* of West and Central Sudan, often allied to the Nubas, with whom they have nothing in common, being originally Hamites, now fused in many places with the surrounding negro peoples; lastly, the *Fans* of the Ogoway basin, the *Masai* east of Lake Victoria, the *Turkanas*, *Rendilehs*, and others of Lake Rudolf, and the *Wahumas*, widely diffused under many names throughout East Central Africa. These also are undoubtedly Hamites, mixed in varying proportions with negro elements.

But the secondary groups of the negroes themselves are not so easily explicable. Here the Sudanese Negroes have in the first place to be distinguished from the multitudinous Bantu Negroid groups, who occupy most of the southern half of the continent, from about 4° or 5° N. lat. to Natal and Pondoland. Although not always easily justified on anatomical grounds, this distinction between the northern Sudanese and southern Bantu sections of the negro family has a practical value and a substantial foundation in the geographical distribution, the mental qualities, and the speech of the two groups. No full-blood Sudanese Negro community has ever developed a political or social system higher than that of the tribal organization, while extensive kingdoms and empires, such as those of the Monomotapa, of the Cazembo, of Lunda, Barotseland, Kongo, and Zululand, based on unwritten codes and military institutions, have flourished often for several generations amongst the Bantu peoples. Nor have any true Soudanese Negroes ever acquired prominence for great intellectual or moral qualities, such as those by which several of the Tushilonge, the Balolo, the Makololo, Bechuana, Basuto, and Zulu-Xosa rulers have been distinguished in former and recent times. In a word, the average Bantu is altogether more intelligent and far more capable of upward development than the average Sudanese Negro.

Very marked from this point of view are the contrasts presented by both groups in the linguistic domain. While all speak languages of the agglutinating order, linguistic chaos prevails in Sudan, linguistic uniformity to a remarkable degree in Bantuland. The numerous dialects current amongst the Bantu peoples and diffused over an area of some 6,000,000 square miles are all reducible to half-a-dozen groups, which are themselves closely related and obviously all sprang from a single stock language presenting some structural features of a high order. *Kongoese*, a typical member of the family, possesses the qualities of precision, flexibility, and subtlety of expression to such an extent that "its daily use is in itself an education" (Rev. W. H. Bentley). In Sudan, on the contrary, the countless local dialects defy classification. The *Nuba* of Kordofan and Nubia differs as profoundly from the *Fulah* of Senegambia, the *Songhay* of the Middle Niger from the *Kanuri* and *Baghirmi* of Lake Chad, as English does from Arabic, or French from Chinese. In a word these Sudanese tongues may be grouped in a large number of families which are radically distinct from each other, and, whatever their origin, can no longer be traced to a single stock.

From these remarks it follows that the term "Sudanese" has a distinctly racial, but no linguistic value, whereas the term "Bantu" is primarily linguistic. It conveys a very clear idea to the philologist, but not to the anthropologist, who finds in the mixed Bantu domain not only every shade of transition between the true negro and the true Hamite, but also some divergent types differing greatly from both. In the tropical forest tracts are scattered numerous groups of Negritoes, or "Little Negroes," true dwarfs, differing not only in their diminutive stature (3 ft. 6 in. to 5 ft.) but also in some other important respects—yellow colour, hirsute bodies, culture (all hunters exclusively)—from the blacks of normal type. Lastly, in the extreme south-west, range the primitive Bushmen, still at the Palæolithic stage, and the neighbouring Hottentots, both presenting some remarkable and highly specialized features, such as the *tablier* and *steatopygia* peculiar to the female sex, and a distinctly yellow complexion common to both. (Art. Bushmen; Hottentots.)

Thus is completed the variegated picture presented by the aboriginal inhabitants of the continent. Of the intruders immeasurably the most important from the ethnical, but no longer from the political, standpoint are the Semites, who arrived from Asia, some in prehistoric, some in historic times, mainly by the Mediterranean and by the two routes at the southern and northern extremities of the Red Sea. Amongst the earliest arrivals were the civilized peoples of Arabia Felix (Yemen), *i.e.*, *Minæans* and *Sabæans*, collectively known as *Himyarites*, or "Red Men" (whence the "Red Sea"), who established themselves about Adulis bay some centuries before the new era. Thence they penetrated gradually into the Abyssinian uplands, founding the Axumite empire, yielding later to the religious and cultural influences of the Alexandrian Greek and Coptic Christians, and intermingling everywhere with the rude Hamitic aborigines (*Agaus*).

Thus were formed the extremely mixed populations of Abyssinia, while the dominant Semitic immigrants continued and continue to hold the political overlordship, founding the three kingdoms of Tigré, Amhara, and Shoa, at present united in the empire of "Ethiopia," as it is officially called. The old Hamitic speech is not extinct, although everywhere somewhat eclipsed by various more or less corrupt forms of Geez, *i.e.*, the archaic Semitic tongue, which was introduced by the Himyarites, still survives in the Marah district of South Arabia, and is the liturgical language of the Abyssinian Christians.

The Himyarites, who took the southern route, were probably preceded by their Phœnician kinsmen, who had already at an early date converted the Mediterranean into a great highway of trade and colonial enterprise. From the great cities of Tyre and Sidon came the founders of the greater cities of Leptis Major, Utica, Carthage, and other Phœnician settlements on the coast lands between the Syrtes and the Atlantic, later merged in the Carthaginian empire, which contended with Rome for the mastery of the ancient world. After the fall of Carthage the Phœnician settlements everywhere became Romanized, and both the Romans and their Vandal conquerors were all in their turn absorbed by the surrounding Hamitic aborigines.

Then came the third great Semitic invasion, that of the fiery *Arab* fanatics, which has modified the ethnical relations of the continent to a far greater extent than all the other intrusions together. Before the close of the 7th century the Moslem Arab hordes had already reached the shores of the Atlantic, and soon after spread over the western Sahara, founded Mohammedan states (Timbuktu, Bornu, Baghirmi, Wadai) on the banks of the Niger and in the Chad basin, penetrated up the Nile valley to and beyond Khartum to the Sobat junction, developing great pastoral communities and even states—Kabbabish, Jaalins, Baggáras, Fúnj empire of Senaar—in the present Anglo-Egyptian Sudan; lastly, established themselves on the eastern seaboard from Cape Guardafui to Sofala beyond the Zambezi, everywhere dominating, but also intermingling with the aboriginal Hamitic, Negro, and Negroid Bantu populations.

Still later the Arabs advanced from the coast lands and the White Nile far inland, ranging over vast spaces westwards to the Upper Congo and southwards to Lakes Tanganyika and Nyasa, in association with their *Nubian*, *Swahili*, *Ajao*, *Manyuema*, and other native allies. Here also were founded some permanent settlements—Mpwapwa, Tabora, Ujiji, Nyangwe, Kota Kota, Riba-Riba, Meshra-er-Rek, Lado—which, however, were not so much Arab colonies as *zeribas*, or strongly-fenced stations, established at convenient strategical points for the purpose of raiding the surrounding lands in quest of ivory and the men required to convey it to the coast, where they were sold as slaves. Hence since the partition of Africa these Arabs, mostly half-breeds, have been cleared out, and the stations transformed to centres of European trade and cultural influences. Thus it happens that in the Congo and Zambezi regions there is but a slight strain of Arab blood, whereas throughout the northern half of the continent Semitic elements are in many places grafted on the original Hamitic and Negritic stocks.

The Moslem Semites were accompanied and even preceded by others, the *Jews* of Palestine, who, however, were nearer akin to their Phœnician forerunners than to the Arabs and Himyarites. They began to arrive probably soon after the Babylonian captivity, and considerable numbers were already settled in Lower Egypt under the Ptolemies. After the fall of Jerusalem and the suppression of the subsequent revolts these were joined by others, many of whom passed westwards and settled in all the large towns and surrounding districts, from Tripoli to Morocco, where, despite ages of oppression, they still form numerous wealthy communities. But, living mostly apart, they have scarcely disturbed the ethnical relations in Africa to any appreciable extent.

The same is true also of the still later immigrants from Europe into the northern and southern extra-tropical zones—*Greeks*, *Italians*, *French*, *Spaniards*, in Egypt and Mauritania, *Dutch* and *British*, with some French and Germans, south of the Zambezi. These intruders have given rise to dislocations and displacements, but not to interminglings, with the notable exception of the early Dutch Boers, from whose alliance with the Hottentots have sprung the so-called "Bastaards," *i.e.*, *Griquas*, *Gonaquas*, and several other half-caste Hottentot groups in Cape Colony and Namaqualand. Both in the Cape and in Natal are several communities of Mohammedan Malays from various parts of the Eastern Archipelago, while numerous Banians (Hindus of the trading caste) are settled in all the coast towns from Durban to Mombasa. Subjoined is a table of all the African populations, indigenous and intruders, from ancient to present times, as far as known:—

A. Caucasic Division.

I. Eastern Hamites:—

Retu, ancient Egyptians; later Copts and Fellahin (mixed), Nile valley from 1st cataract to the Delta.

Blemmyes; Bugaitæ, now Begas, Bejas; Ababdeh; Hadendowa; Bishari; Beni-Amer, from Nile to Red Sea between Egypt and Abyssinia.

Athagao, Agao, Agaomedir ("Agaoland") and other parts of Abyssinia.
Afar (Danakil), between Abyssinia, Red Sea, and Gulf of Aden.
Somali; *Gallas*; Somali and Galla lands.
Turkana; *Rendileh*; Lake Rudolf district.
Masai; *Wakwafi*; Mau plateau between Great Rift-Valley and Lake Victoria.
Wahuma, intermingled with the Bantus in the equatorial lake region.

II. WESTERN HAMITES:—
Mahurim ("Westerns"), so called by the Carthaginians, whence Mauri, "Moors," call themselves *Imazighen*, "Freemen"; Maziges, Numidæ, Gætuli, Leucæthiopes, all now known as "Berbers"; Shellalas (Shluhs) of the western Atlas; Kabyles of North Morocco and Algeria; Shawiahs, Zenagas, Beni-Mzabs of Algeria and Tunisia; Haratin ("Black Berbers") of the southern Atlas; Tuaregs of the western Sahara.
Tamahu (*Libyans*), Nasomones; Aujilas; Hammonii; Siwahs, Cyrenaica and Siwah oasis.
Garamantes, *Tedamansi*, Tedas and Dazas (northern and southern *Tibbus*), Tibesti range and the oases of the eastern Sahara.

III. SEMITES:—
Himyarites, Axumites; Tigriñas; Amhariñas; Shoas; north, central, and south Abyssinia.
Phœnicians, Carthage and Mauritanian coast lands (extinct).
Arabs (mostly Bedouins), Egypt, Anglo-Egyptian Sudan, Tripolitana, Mauritania, western Sahara, central Sudan, east coast southwards to Sofala.
Jews, Egypt, Tripolitana, Mauritania.

IV. EUROPEANS:—
Hellenes, Cyrenaica, Nile Delta (extinct).
Romans }
Vandals } Africa Provincia, Mauritania (extinct).
Modern Greeks, Egypt, Anglo-Egyptian Sudan.
Maltese }
Italians }
French } Egypt, and thence to Morocco; Canary Islands (Spaniards).
Spaniards }
Dutch, *Huguenots* (extinct), Cape Colony, Natal, the late Boer States.
Britons, Cape, Natal, late Boer States, North and South Rhodesia, Nyasaland, East and West Coast sporadically.
Germans, The Cape, Transvaal, elsewhere sporadically.
Portuguese, East and West Coasts, São Thomé, Cape Verde Islands, Madeira, Azores.

B. NEGRITIC DIVISION.

I. SUDANESE NEGROES }
II. BANTU NEGROIDS } Full details in Art. NEGRO.
III. BUSHMEN, formerly ranged from Tanganyika to the Cape, now mainly confined to the Kalahari Desert (Art. BUSHMEN).
IV. HOTTENTOTS (Khoi-Khoin):—
Namaqua, Great and Little Namaqualand.
Koraqua, Upper Orange and Vaal rivers.
Griqua, Griqualand East.
Gonaqua, Cape Colony, Eastern Provinces.
All except the Namaqua are Dutch-Hottentot or Bantu-Hottentot half-breeds.
V. NEGRITOES:—
Danga (*Tank*) in Egypt from Shade-land beyond Punt (Somaliland) 3300 B.C.
Akkas }
Wochuas }
Achuas } Welle, Aruwimi and Semliki river valleys.
Wambutti }
Dumes }
Dokos } South Gallaland, Lake Rudolf district, Masai-
Wanderobos } land.
Babinga, Middle Sangha, northern tributary, Congo.
Batwa, Sankuru river, southern tributary, Congo.
Ahongo, Akoa (Okoa). Okande district, Ogoway basin.
Obongo, Ashiraland, Ogoway basin.
Vaalpens, Middle Limpopo river, North Transvaal.

(A. H. K.)

III. RECENT POLITICAL HISTORY.

Africa is the last of the continents to be annexed by the nations of Europe, and the process of annexation presents many features which have no parallel in the previous history of the relations of the white with the coloured races. Until 1875 Europe had concerned herself politically mainly with the northern and southern extremities of the continent, and with a narrow strip along the eastern and western seaboards. There were vast areas in the interior which were still unexplored, but the explorer had penetrated far beyond the limits of European political influence, and in 1875 the explorer did not necessarily include a batch of ready-made treaties among his outfit. It would be interesting to discuss the causes which have, directly or indirectly, led to the extraordinary activity which the Great Powers of Western Europe have displayed in annexing and marking out spheres of influence in the African continent. But such an inquiry would involve a review of the whole field of European politics, and it must be sufficient, before proceeding to a recapitulation of the steps by which Europe has absorbed Africa, to indicate one or two of the main factors in the situation. The Franco-German war of 1870 must be regarded as the real starting-point in the movement. From that war Germany emerged strong and united, eager for new worlds to conquer. France, after the first shock of despair had passed away, began to develop fresh stores of reserve energy, and her statesmen and people, half unconsciously at first, but later of set design, sought to find outside Europe compensation for her lost provinces on the Rhine. France and Germany were both, therefore, ripe for a policy of colonial expansion, and a rapid survey of the land-masses of the globe made it clear that Africa, alone among the continents, offered adequate opportunities for satisfying this new-born land hunger. France still possessed some remnants of her former colonial possessions, and in Northern Africa, and on the Atlantic seaboard, had a firm foothold on the continent. Germany was entirely without colonies, either in Africa or elsewhere. The more temperate regions of the earth had already been acquired by the colonizing Powers that were earlier in the field, and the more accessible parts of the tropics had also been earmarked as British, Dutch, Spanish, or Portuguese. Africa alone, therefore, offered any large field for the resuscitated energies of France, or the virgin activities of Germany; and the history of the modern partition of Africa is mainly a record of the struggles of these two Powers and of Great Britain to secure for themselves as large a share as possible of the continent. The part played by Leopold II., King of the Belgians, in the founding of the Congo Free State, and in the opening up of the continent to the political influence of Europe, furnishes a remarkable episode in that history; but France, Germany, and Great Britain are the principal actors in the drama, and in following the various stages in the work of partition it is necessary, for a proper understanding of the part which each of these three Powers played, to remember that France was the first consciously to recognize the magnitude of the undertaking and the need for speed in its accomplishment; that, in Germany, Prince Bismarck, at the instigation of a small but influential body of "Kolonial-Menschen," took the first steps in the direction of colonial expansion, not only in advance of German public opinion, but before other countries, or at least Great Britain, had realized that Germany was seriously entering the lists as a colonial Power; and finally that Great Britain, though more favourably placed than either of her rivals, was, from a variety of causes, the last to realize the need for action and the urgency of the situation.

Causes of European activity.

The position of Great Britain requires a few words of explanation. She was already in possession of a vast colonial empire, widely distributed over the globe. It was a favourite conception of the public men of the middle half of the 19th century that colonies were quite as much a burden as a blessing, and that, at no very remote period, the young communities which had settled in distant lands under the British flag would shake themselves free from the control of the mother-country, and begin an independent existence, as soon as they felt themselves able to walk alone. There was a strong disinclination to increase Great Britain's commitments abroad, and in Africa the repeated solicitations of native kings and chiefs in the neighbourhood of British settlements, to be taken under British protection, were rejected in pursuance of a deliberately adopted policy. In 1865 a strong representative committee of the House of Commons unanimously resolved "that all further extension of territory or assumption of government, or new treaty offering any protection to native tribes, would be inexpedient." But while the overtures of native kings were rejected, the fact that they were made, coupled with the further fact that the exploration of the continent had been mainly undertaken by British subjects, or under British auspices, gave rise to the feeling that, in some not very clearly defined way, Great Britain had a sort of vague claim over regions, which, if they were not British, were not claimed by any other European Power. It was not until France had fairly entered on her career of annexation in West Africa, and Germany had entered the field, that the British Government and the British public awoke to the consciousness of the fact that there was no time to be lost if Great Britain was to take her part in the "scramble."

The position in 1875.

A brief survey of the political situation, and of the position of the European Powers in Africa, at the beginning of the last quarter of the 19th century, will form a fitting prelude to the history of the modern partition of the continent. In 1875 Egypt was under the rule of Ishmail Pasha, who had, two years before, been granted by the Sultan the right of concluding treaties with foreign Powers and of maintaining armies. The Khedive's troops had by this time pushed their way southwards along the Nile valley, and had established Egyptian rule in Darfur and Kordofan, while Egyptian influence may be said to have extended right up to the Albert Nyanza. Tripoli was then, as now, a province of the Turkish empire. Morocco, then as now, was an independent state, while Algeria, which had been conquered by France in the second quarter of the century, had been for four years under civil administration so far as the coast regions were concerned, though military rule was still maintained in the interior, and the Saharan tribes did not recognize French authority in any form. On the west coast France had, since the 17th century, been settled at the mouth of the Senegal river, and had made successive advances into the interior towards the valley of the Upper Niger. On the coast her influence was recognized by treaty, from Cape Blanco to the British settlements on the Gambia, and a considerable region had been brought under some sort of administrative control. Below the Gambia France touched the coast again at Casamance, and had extended her influence for some distance towards the interior. On the Ivory Coast France had acquired vague rights, which were turned to good account in the subsequent scramble at Grand Bassam and Assinie, but in 1875 she had taken no practical steps to occupy and administer even these isolated points. The same observation applies to Porto Novo, where France had acquired some sort of footing which enabled her to lay the foundation of her present colony of Dahomey. Farther down the coast the French had establishments at the estuary of the Gabun and on the Ogowé river, but M. Savorgnan de Brazza had not yet begun the work of founding the French Congo Colony. Save for the islands of Réunion, St Marie, Mayotte, and Nossi-Bé, and for the port of Obok, near the southern entrance to the Red Sea—which had been acquired by purchase in 1862, though it was not effectively occupied till 1883—this exhausts the list of French possessions in Africa in 1875.

Spanish possessions in Africa at the same date consisted of the Canary Islands, an old fort on the Rio d'Oro,—on the ownership of which Spain subsequently based claims to the stretch of coast between the southern limits of Morocco and France's Senegambian possessions, extending from Cape Bojador to Cape Blanco, a distance of some 500 miles,—the island of Fernando Po in the Gulf of Guinea, and a small strip of territory on the banks of the Muni river, which was also claimed by France.

The position of Portugal in Africa in 1875 is very difficult to define. The glorious record of the Portuguese in the exploration of the continent cannot be recapitulated here. But on the strength of her achievements in the past Portugal put forward claims which were as vague as they were extensive, and which the other European Powers interested in Africa firmly refused to recognize. Compared with the claims which she subsequently made, the area of African territory which was actually administered by Portugal in 1875 was ludicrously small. Apart from her island possessions Portugal had a small settlement on the Guinea Coast, south of the French settlement of Casamance, another small settlement at Kabinda, north of the estuary of the Congo, and more extensive possessions south of that river, constituting the provinces of Loanda, Benguela, and Mossamedes. On the east of the continent the Portuguese were settled at Sofala, Mozambique, and other parts of the coast, but their administration was sunk in lethargy, and it is impossible to say, with any approach to accuracy, what were the limits within which they exercised any effective supervision. It was, however, in 1875 that Marshal MacMahon, the then President of the French Republic, settled the long-standing dispute between Great Britain and Portugal for the possession of Delagoa Bay in favour of the latter Power.

In 1875 Great Britain was without question, both as regards the area and the importance of her possessions, the European Power most considerably interested in Africa. But her interests were not confined to territorial rights. British explorers, missionaries, and traders had established British "influence" in various regions of the continent, without obtaining, and in some cases without seeking, Government sanction. For this apparent slackness in regularizing British interests by formal engagements there were two reasons. In the first place the home Government, acting in pursuance of the resolution of 1865, was unwilling to extend the area of its obligations; and in the second place, except in West Africa, where France had shown considerable activity, little or no fear was entertained of the competition of other European Powers. Native chiefs, in many parts of the continent which are now included in non-British spheres of influence, petitioned for British protection; but their requests were refused, partly because of an unwillingness to extend responsibilities beyond the coast, and partly because it was assumed that Great Britain could at any moment take formal possession, should it suit her purpose to do so. In this way British influence "predominated" on the Niger and in the Sultanate of Zanzibar, but in neither case had that predominating influence found formal expression, and when the scramble suddenly began, intruding rivals forced Great Britain to defend her position, which she was only able to make good by considerable sacrifices. At the beginning of the last quarter of the 19th century Great Britain had in fact no recognized footing on the eastern mainland of the African continent north of Natal, the area of which colony was at that period estimated at less than 12,000 square miles. To the north of Natal, along the coast, Zululand was still independent. South of Natal, Pondoland was also independent, and there were other isolated patches of territory which had not been brought under British rule; but with these comparatively unimportant exceptions the whole of the southern end of the continent, up to the Orange river and the Orange Free State, was British. Basutoland had been annexed in 1868, and three years later had been added to Cape Colony. In 1875 the estimated area of Cape Colony, including British Kaffraria and Basutoland, was 201,000 square miles. Between the Orange river and the Vaal was the Orange Free State, and farther to the north the Transvaal was still an independent republic. On the west coast of Africa Great Britain's possessions were little more than coast settlements, with more or less ill defined relations with the tribes of the interior, established for purposes of trade rather than of administration. Passing up the west coast from the Orange river, the first British territory reached was, in 1875, the Gold Coast Colony, which included the island of Lagos and a strip of the adjacent coast land, as well as the British settlements on the Gold Coast proper. Four years previously, in 1871, the possessions of Great Britain on the coast had been extended by the transfer, for a money consideration, of the Dutch settlements to Great Britain, but even so British authority did not extend any considerable distance from the coast, and the whole area of the Gold Coast settlements proper was roughly estimated at some 6000 square miles. Still farther round the coast was the then still smaller colony of Sierra Leone, and still farther to the north was the last of the West African settlements, on the Gambia river, at that time estimated to have an area of only 21 square miles.

Neither Germany nor Italy had at this time set foot on the continent, nor had the Congo Free State begun to take shape in the mind of its founder. Besides the independent states already named, there were Abyssinia in the north-east; the Sultanate of Zanzibar on the east coast, including the islands of Zanzibar and Pemba, and a large tract of territory on the mainland with no very clearly defined boundaries; and on the west coast the negro republic of Liberia, which had been established in 1820 as an experiment by the Washington Colonization Society, and had been recognized as an independent state by the European Powers in 1847.

Such, in brief outline, was the political condition of Africa in 1875. In the interior, much of which was either wholly unknown or but very imperfectly known to Europeans, there were considerable native kingdoms, but the materials for fixing their limits at any given moment are extremely scanty, and in dealing with the partition of Africa among the Powers of Europe it is unnecessary to attempt to describe the political condition of the interior of the continent. It may, however, be useful before proceeding further to attempt to tabulate the political position in continental Africa in 1875, for the purpose of comparison with the subsequent table showing the partition of the continent in 1900. It must be borne in mind that the figures given are in almost all cases approximate, and have little positive value in themselves:—

POSITION IN 1875.

	Area in sq. Miles.
GREAT BRITAIN—	
Cape Colony	201,000
Griqualand West	17,800
Natal	11,172
Lagos	5,000
Gold Coast	6,000
Sierra Leone	468
Gambia	21
Total British Africa	241,461
FRANCE—	
Algeria	150,500
Senegambia	10,000
Guinea Coast and Gabun	7,750
Total French Africa	168,250
PORTUGAL—	
Senegambia and Guinea	1,687
Angola	14,700
Mozambique	18,000
Total Portuguese Africa	34,387
SPAIN—	
Ceuta, &c.,	3
Muni river settlements	850
Total Spanish Africa	853
NON-EUROPEAN STATES—	
Transvaal	110,000
Orange Free State	49,000
Liberia	14,300
Egypt and Sudan	1,406,250
Tunis	42,000
Morocco	219,000
Abyssinia Zanzibar	No estimate.

King Leopold and the Brussels Conference, 1876.

Many circumstances had combined to arouse the interest of Europe in the hitherto neglected continent of Africa. Narratives of travel by such men as Rebmann, Krapf, Burton, Speke and Grant, Schweinfurth, Nachtigal, Livingstone, and Stanley, had stimulated interest outside geographical circles. Livingstone's tragic death in the heart of the continent, and Stanley's letters from Uganda, where he arrived in April 1875, had aroused the enthusiasm of the missionary societies, while the importance of finding new markets was turning the thoughts of the manufacturing and trading classes to the possibility of Africa as a centre of commercial enterprise. The psychological moment had arrived, and with it the man who was to shape these inchoate forces to a definite end. Leopold, King of the Belgians, the sovereign of one of the smallest states of Europe, found in the narrow limits of his kingdom an insufficient field for his restless energies and ambitions. He had travelled in the Far East, and had entertained thoughts of founding a colony in that part of the world. But Africa fascinated him as it did so many less distinguished personages. The vast area of the almost virgin continent offered an apparently illimitable field, both for scientific exploration and for commercial development; and in September 1876 King Leopold took what may be described as the first definite step in the modern partition of the continent. He summoned to a conference at Brussels representatives of Great Britain, Belgium, France, Germany, Austria-Hungary, Italy, and Russia, to deliberate on the best methods to be adopted for the exploration and civilization of Africa, and the opening up of the interior of the continent to commerce and industry. The conference was entirely unofficial. The delegates who attended neither represented nor pledged their respective Governments. Their deliberations lasted three days, and resulted in the foundation of "The International African Association," with its headquarters at Brussels. It was further resolved to establish national committees in the various countries represented, which should collect funds and appoint delegates to the International Association. The central idea appears to have been to put the exploration and development of Africa upon an international footing. But it quickly became apparent that this was an unattainable ideal. The national committees were soon working independently of the International Association, and the Association itself passed through a succession of stages until it became purely Belgian in character, and at last developed into the Congo Free State, under the personal sovereignty of King Leopold. At first the Association devoted itself to sending expeditions to the great central lakes from the east coast; but failure, more or less complete, attended its efforts in this direction, and it was not until the return of Stanley from his great journey down the Congo in January 1878, that its ruling spirit, King Leopold, definitely turned his thoughts towards the Congo. In June of that year, Mr Stanley visited the king at Brussels, and in the following November a private conference was held, and a committee was appointed for the investigation of the Upper Congo.

Stanley and the Congo.

Mr Stanley's remarkable discovery had stirred ambition in other capitals than Brussels. France had always taken a keen interest in West Africa, and in the years 1875 to 1878 M. Savorgnan de Brazza had carried out a successful exploration of the Ogowé river to the south of the Gabun. M. de Brazza determined that the Ogowé did not offer that great waterway into the interior of which he was in search, and he returned to Europe without having heard of the discoveries of Mr Stanley farther south. Naturally, however, Mr Stanley's discoveries were keenly followed in France. In Portugal, too, the discovery of the Congo with its magnificent unbroken waterway of more than a thousand miles into the heart of the continent, served to revive the languid energies of the Portuguese, who promptly began to furbish up claims whose age was in inverse ratio to their validity. Claims, annexations, and occupations were in the air, and when in January 1879, Mr Stanley left Europe as the accredited agent of King Leopold and the Congo committee, the strictest secrecy was observed as to his real aims and intentions. The expedition was, it was alleged, proceeding up the Congo to assist the Belgian expedition which had entered from the east coast, and Mr Stanley himself went first to Zanzibar. But in August 1879 Mr Stanley found himself again at Banana Point, at the mouth of the Congo, with, as he himself has written, "the novel mission of sowing along its banks civilized settlements to peacefully conquer and subdue it, to remould it in harmony with modern ideas into national states, within whose limits the European merchant shall go hand in hand with the dark African trader, and justice and law and order shall prevail, and murder and lawlessness and the cruel barter of slaves shall be overcome." The irony of human aspirations was never perhaps more plainly demonstrated than in the contrast between the ideal thus set before themselves by those who employed Mr Stanley, and the actual results of their intervention in Africa. Mr Stanley founded his first station at Vivi, between the mouth of the Congo and the rapids that obstruct its course where it breaks over the western edge of the central continental plateau. Above the rapids he established a station on Stanley Pool and named it Leopoldville, founding other stations on the main stream in the direction of the falls that bear his name.

French rivalry.

Meanwhile M. de Brazza was far from idle. He had returned to Africa towards the end of the same year which saw Stanley back on the Congo, and while the agents of King Leopold were making treaties and founding stations along the southern bank of the river, M. de Brazza and other French agents were equally busy on the northern bank. M. de Brazza was sent out to Africa by the French committee of the International African Association, which provided him with the funds for the expedition. His avowed object was to explore the region between the Gabun and Lake Chad. But there is not much doubt that his real object was to anticipate Mr Stanley on the Congo. The international character of the association founded by King Leopold was never more than a polite fiction, and the rivalry between the French and the Belgians on the Congo was soon open if not avowed. In October 1880 M. de Brazza made a solemn treaty with a chief on the north bank of the Congo, who claimed that his authority extended over a large area, including territory on the southern bank of the river. As soon as this chief had accepted French protection, M. de Brazza crossed over to the south of the river, and founded a station close to the present site of Leopoldville. The discovery of the French station by Mr Stanley naturally annoyed King Leopold's agent, and he promptly challenged the rights of the chief who purported to have placed the country under French protection, and himself founded a Belgian station close to the site selected by M. de Brazza. In the result, the French station was withdrawn to the northern side of Stanley Pool, where it is now known as Brazzaville.

Portuguese claims.

The activity of French and Belgian agents in the Congo had not passed unnoticed in Lisbon, and the Portuguese Government saw that no time was to be lost if the claims it had never ceased to put forward on the west coast were not to go by default. At varying periods during the 19th century Portugal had put forward claims to the whole of the West African coast, between 5° 12′ and 8° south latitude. North of the Congo mouth, she claimed the territories of Kabinda and Molemba, alleging that they had been in her possession since 1484. Great Britain had never, however, admitted this claim, and south of the Congo had declined to recognize Portuguese possessions as extending north of Ambriz. In 1856 orders were given to British cruisers to prevent by force any attempt to extend Portuguese dominion north of that place. But the Portuguese had been persistent in urging their claims, and in 1882 negotiations were again opened with the British Government for recognition of Portuguese rights over both banks of the Congo on the coast, and for some distance inland. Into the details of the negotiations, which were conducted for Great Britain by Lord Granville, who was then Secretary for Foreign Affairs, it is unnecessary to enter; they resulted in the signing on the 26th February 1884 of an agreement, by which Great Britain recognized the sovereignty of the king of Portugal "over that part of the west coast of Africa, situated between 8° and 5° 12′ south latitude," and inland as far as Nokki, on the south bank of the Congo, below Vivi. The navigation of the Congo was to be controlled by an Anglo-Portuguese commission. The publication of this treaty evoked immediate protests, not only on the Continent, but in Great Britain. In face of the universal disapproval aroused by the agreement, Lord Granville found himself unable to ratify it. The protests had not been confined to France and the King of the Belgians. Germany had not yet acquired formal footing in Africa, but she was crouching for the spring prior to taking her part in the scramble, and Prince Bismarck had expressed, in vigorous language, the objections entertained by Germany to the Anglo-Portuguese agreement.

For some time before 1884 there had been growing up a general conviction that it would be desirable, for the Powers who were interesting themselves in Africa, to come to some agreement as to "the rules of the game," and to define their respective interests so far as that was practicable. Lord Granville's ill-fared treaty brought this sentiment to a head, and it was agreed to hold an international conference on African affairs. But before discussing the Berlin Conference of 1884-85, it will be well to see what was the position, on the eve of the conference, in other parts of the African continent. In the southern section of Africa, south of the Zambezi,

Great Britain in South Africa.

important events had been happening. In 1876 Great Britain had concluded an agreement with the Orange Free State for an adjustment of frontiers, the result of which was to leave the Kimberley diamond fields in British territory, in exchange for a payment of £90,000 to the Orange Free State. On the 12th April 1877, Sir Theophilus Shepstone had issued a proclamation declaring the Transvaal—the South African Republic, as it was formerly designated—to be British territory. (See TRANSVAAL.) On the 29th September 1879, Sir Garnet Wolseley, the commander-in-chief in South Africa, issued another proclamation, declaring the Transvaal to be for ever an integral portion of the British dominions in South Africa. In December 1880 war broke out, and lasted until March 1881, when a treaty of peace was signed. This treaty of peace was followed by a convention, signed in August of the same year, under which complete self-government was guaranteed to the inhabitants of the Transvaal, subject to the suzerainty of Great Britain, upon certain terms and conditions and subject to certain reservations and limitations. No sooner was the convention signed than it became the object of the Boers to obtain a modification of the conditions and limitations imposed, and in February 1884 a fresh convention was signed, amending the convention of 1881. Article IV. of the new convention provided that "The South African Republic will conclude no treaty or engagement with any state or nation other than the Orange Free State, nor with any native tribe to the eastward or westward of the Republic, until the same has been approved by Her Majesty the Queen." The precise effect of the two conventions has been the occasion for interminable discussions, but as the subject is now one of merely academic interest, it is sufficient to say that when the Berlin Conference held its first meeting in 1884 the Transvaal was practically independent, so far as its internal administration was concerned, while its foreign relations were subject to the control just quoted. As early as 1875, in a protocol attached to a treaty of friendship, commerce, and boundaries, between the Transvaal and Portugal, an agreement had been made for the construction of a line between Delagoa Bay and Pretoria; and in 1884 a further agreement was made between the same parties to the same effect, both agreements receiving the sanction of Queen Victoria as suzerain.

But although the Transvaal had thus, between the years 1875-84, become and ceased to be British territory, British influence in other parts of Africa south of the Zambezi had been steadily extended. To the west of the Orange Free State, Griqualand West was annexed to the Cape in 1877, while to the east the territories beyond the Kei river were included in Cape Colony between 1877 and 1884, so that in the latter year, with the exception of Pondoland, the whole of South-East Africa up to Natal was in one form or another under British control. North of Natal, Zululand was not actually annexed until 1887, although since the 1879 war, and the restoration of Cetewayo in 1882, British influence had been admittedly supreme. In December 1884 St Lucia Bay had been proclaimed a British possession, and three years later an agreement of non-cession to foreign powers made by Great Britain with the regent and paramount chief of Tongaland, completed the chain of British possessions on the coast of South Africa, from the mouth of the Orange river on the west to Kosi Bay and the Portuguese frontier on the east. In the interior of South Africa, the year 1884 witnessed the beginning of that final stage of the British advance towards the north which was eventually to extend British influence from the Cape to the southern shores of Lake Tanganyika. The activity of the Germans on the west, and of the Boer republic on the east, had brought home to both the imperial and colonial authorities the impossibility of relying on vague traditional claims. In May 1884 treaties were made with native chiefs by which the whole of the country north of Cape Colony, west of the Transvaal, south of 22° S. latitude, and east of 20° E. longitude was placed under British protection, though a protectorate was not formally declared until the following January. The southern portion of this newly-acquired territory up to the Molopo river was in September 1875, under the name of British Bechuanaland, placed under the jurisdiction of the governor of Cape Colony, while the territory north of the Molopo river and south of 22° S. latitude, which included Khama's country, Bathoen's country, Sebele's country, and the Kalahari desert, was at the same time declared a British protectorate, the local administration being left in the hands of the native chiefs.

Germany in South-West Africa.

Meanwhile some very interesting events had been taking place on the west coast, north of the Orange river, and south of the Portuguese province of Mossamedes. In Germany a variety of circumstances had conspired to turn the thoughts of both the rulers and the ruled towards the acquisition of territories overseas, where German colonists could settle under the German flag. It must be sufficient here to touch very briefly on the events that preceded the foundation of what is now the colony of German South-West Africa. For many years prior to 1884, German missionaries had settled among the Damaras and Namaquas, often combining small trading operations with their missionary work. From time to time trouble arose between the missionaries and the native chiefs, and appeals were made to the German Government for protection. The German Government in its turn begged the British Government to say whether it assumed responsibility for the protection of Europeans in Damaraland and Namaqualand. The position of the British Government was intelligible, if not very intelligent. It did not desire to see any other European Power in these countries, and it did not want to assume the responsibility and incur the expense of protecting the few Europeans settled there. Sir Bartle Frere, when Governor of the Cape (1877-81), had foreseen that this attitude portended trouble, and had urged that the whole of the unoccupied coast-line, up to the Portuguese frontier, should be declared under British protection. But he preached to deaf ears, and it was as something of a concession to him that in March 1878 the British flag was hoisted at Walfisch Bay, and the country for a radius of 15 miles was declared to be British. The fact appears to be that British statesmen failed to understand the change that had come over Germany. They believed that Prince Bismarck would never give his sanction to the creation of a colonial empire, and, to the German inquiries as to what rights Great Britain claimed in Damaraland and Namaqualand, procrastinating replies were sent. Meanwhile the various colonial societies established in Germany had effected a revolution in public opinion, and, more important still, they had convinced the great Chancellor. Accordingly when, in November 1882, Herr Luderitz, a Bremen merchant, informed the German Government of his intention to establish a factory on the coast between the Orange river and the Little Fish river, and asked if he might rely on the protection of his Government in case of need, he met with no discouragement from Prince Bismarck. In February 1883 the German ambassador in London informed Lord Granville of Herr Luderitz's design, and asked "whether Her Majesty's Government exercise any authority in that locality." It was intimated that if Her

Majesty's Government did not, the German Government would extend to Herr Lüderitz's factory "the same measure of protection which they give to their subjects in remote parts of the world, but without having the least design to establish any footing in South Africa." An inconclusive reply was sent, and on the 9th April Herr Lüderitz's agent landed at Angra Pequeña, and after a short delay concluded a treaty with the local chief, by which some 215 square miles around Angra Pequeña Bay were ceded to Herr Lüderitz. In England and at the Cape irritation at the news was mingled with incredulity, and it was fully anticipated that Herr Lüderitz would be disavowed by his Government. But for this belief, it can scarcely be doubted that the rest of the unoccupied coast-line would have been promptly declared under British protection. In the month of August the German Government intimated to their consular representative at the Cape their preparedness to take Herr Lüderitz's concessions under the protection of the Imperial Government. In November the German ambassador again inquired if Great Britain made any claim over this coast, and Lord Granville replied that Her Majesty exercised sovereignty only over certain parts of the coast, as at Walfisch Bay, and suggested that arrangements might be made by which Germany might assist in the settlement of Angra Pequeña. By this time Herr Lüderitz had extended his acquisitions southwards to the Orange river, which had been declared by the British Government to be the northern frontier of Cape Colony. Both at the Cape and in England it was now realized that Germany had broken away from her former purely Continental policy, and, when too late, the Cape parliament showed great eagerness to acquire the territory which had lain so long at its very doors, to be had for the taking. It is not necessary to follow the course of the subsequent negotiations. On the 15th August 1884 an official note was addressed by the German consul at Capetown to the High Commissioner, intimating that the German Emperor had by proclamation taken "the territory belonging to Mr A. Lüderitz on the west coast of Africa under the direct protection of His Majesty." This proclamation covered the coast-line from the north bank of the Orange river to 26° S. latitude, and 20 geographical miles inland, including "the islands belonging thereto by the law of nations." On the 8th of the following month—September 1884—the German Government intimated to Her Majesty's Government, "that the west coast of Africa from 26° S. latitude to Cape Frio, excepting Walfisch Bay, had been placed under the protection of the German Emperor." Thus, before the end of the year 1884, the foundations of Germany's colonial empire had been laid in South-West Africa.

West Africa.

In April of that year Prince Bismarck intimated to the British Government, through the German chargé d'affaires in London, that "the Imperial consul-general, Dr Nachtigal, has been commissioned by my Government to visit the west coast of Africa in the course of the next few months, in order to complete the information now in the possession of the Foreign Office at Berlin, on the state of German commerce on that coast. With this object Dr Nachtigal will shortly embark at Lisbon, on board the gunboat *Möwe*. He will put himself into communication with the authorities in the British possessions on the said coast, and is authorized to conduct, on behalf of the Imperial Government, negotiations connected with certain questions. I venture," the official communication proceeds, "in accordance with my instructions, to beg your excellency to be so good as to cause the authorities in the British possessions in West Africa to be furnished with suitable recommendations." Although at the date of this communication it must have been apparent, from what was happening in South Africa, that Germany was prepared to enter on a policy of colonial expansion, and although the wording of the letter was studiously vague, it does not seem to have occurred to the British Government that the real object of Dr Nachtigal's journey was to make other annexations on the west coast. Yet such was indeed his mission. German traders and missionaries had been particularly active of late years on the coast of the Gulf of Guinea. German factories were dotted all along the coast in districts under British protection, under French protection, and under the definite protection of no European Power at all. It was to these latter places that Dr Nachtigal turned his attention. The net result of his operations was that on the 5th July 1884 a treaty was signed with the king of Togo, placing his country under German protection, and that just one week later a German protectorate was proclaimed over the whole of the Cameroon district. Before either of these events had occurred Great Britain had become alive to the fact that she could no longer dally with the subject, if she desired to consolidate her possessions in West Africa. The British Government had again and again refused to accord native chiefs the protection they demanded. The Cameroon chiefs had several times asked for British protection, and always in vain. But at last it became apparent, even to the official mind, that rapid changes were being effected in Africa, and on the 16th May Consul Hewett received instructions to return to the west coast and to make arrangements for extending British protection over certain regions. He arrived too late to save either Togoland or Cameroon, in the latter case arriving five days after King Bell and the other chiefs on the river had signed treaties with Dr Nachtigal. But the British consul was in time to secure the delta of the river Niger and the Oil Rivers District, extending from Rio del Rey to the Lagos frontier, where for a long period British traders had held almost a monopoly of the trade. Meanwhile France, too, had been busy treaty-making. During the year 1884 no less than forty-two treaties were concluded with native chiefs, an even larger number having been concluded in the previous twelve months. While the British Government still remained under the spell of the fatal resolution of 1865, the French Government was strenuously endeavouring to extend France's influence in West Africa, in the countries lying behind the coast-line. In the campaign of 1880-81 Captain Gallieni advanced as far as Bammako, on the Upper Niger, and other French officials were steadily pursuing the policy which has resulted in surrounding all the old British possessions in West Africa with a continuous band of French territory. In 1881 a preliminary step was taken in a project which, still unrealized, has always exercised a strange fascination over that section of public opinion in France which mostly concerns itself with African affairs. To join France's possessions on the Mediterranean with her colonies in West Africa, by means of a railway is, with many Frenchmen, a haunting ambition. We need not consider the strategical, political, and commercial arguments which are advanced in favour of the proposed trans-Saharan railway, or discuss the difficulties which surround the accomplishment of this grandiose conception. But, in 1881, an expedition was sent from Algeria to make a preliminary survey and report. It was under the command of Colonel Flatters, and had not advanced very far into the desert before it was attacked by the Tuaregs and massacred.

There was, however, one region on the west coast where, notwithstanding the lethargy of the British Government, British interests were being vigorously pushed, protected, *The Niger.*

and consolidated. This was on the Lower Niger, and the leading spirit in the enterprise was Sir George Taubman Goldie. After the discovery of the course of the Lower Niger in 1829 several expeditions had been undertaken, both by the British Government and by private persons, up the river, but owing to the opposition of the tribes who acted as middlemen between the European traders on the coast and the native traders in the interior, and to the unhealthy climatic conditions, very little progress was made in opening up communication with the inland tribes. Factories were established on the Niger delta and on the Oil Rivers creeks by several trading firms, mostly hailing from Liverpool and Glasgow, but up to the year 1879 nothing was done to secure joint action. In that year the various trading firms on the Lower Niger formed themselves into the "United African Company," and the foundations were laid of something like settled administration. An application was made to the British Government for a charter in 1881, and the capital of the company increased to a million sterling. Henceforth the company was known as the "National African Company," and it was acknowledged that its object was not only to develop the trade of the Lower Niger, but to extend its operations to the middle reaches of the river, and to open up direct relations with the great Fulah empire of Sokoto and the smaller states associated with Sokoto under a somewhat loosely-defined suzerainty. The great development of trade which followed the combination of British interests carried out under the skilful guidance of Mr Goldie-Taubman (now Sir George Goldie) did not pass unnoticed in France, and, encouraged by Gambetta, French traders made a bold bid for a position on the river. Two French companies, with ample capital, were formed, and various stations were established on the Lower Niger. Sir George Goldie realized at once the seriousness of the situation, and lost no time in declaring commercial war on the new comers. His bold tactics were entirely successful, and a few days before the meeting of the Berlin Conference he had the satisfaction of announcing that he had bought out the whole of the French interests on the river, and that Great Britain alone possessed any interests on the Lower Niger.

The position in North and East Africa.

To complete the survey of the political situation in Africa, when the plenipotentiaries met at Berlin, it is necessary to refer briefly to the course of events in North and East Africa since 1875. In 1881 the French army entered Tunis, and compelled the Bey to sign a treaty placing that country under French protection. The Sultan of Turkey formally protested against this invasion of Ottoman rights, but the Great Powers took no action, and France was left in undisturbed possession of her newly-acquired territory. In Egypt the joint control exercised by Great Britain and France under the Khedival decree of 10th November 1879 had broken down, owing to the refusal of France to join in the suppression of the Arabi Pasha rebellion, and had been abolished by the decree of 18th January 1883; since which date Great Britain had assumed a predominant position in Egyptian affairs. (See EGYPT.) In East Africa, north of the Portuguese possessions, where the Sultan of Zanzibar was the most considerable native potentate, Germany was secretly preparing the foundations of her present colony of German East Africa. But no overt act had warned Europe of what was impending. The story of the foundation of German East Africa is one of the romances of the continent. Early in 1884 the Society for German Colonization was founded, with the avowed object of furthering the newly-awakened colonial aspirations of the German people. It was a society inspired and controlled by young men, and on the 4th November 1884, eleven days before the conference assembled at Berlin, three young Germans arrived as deck passengers at Zanzibar. They were disguised as mechanics, but were in fact Dr Carl Peters the president of the Colonization Society, Joachim Count Pfeil, and Dr Juhlke, and their stock-in-trade consisted of a number of German flags and a supply of blank treaty forms. They proposed to land on the mainland opposite Zanzibar, and to conclude treaties in the back country with native chiefs placing their territories under German protection. The enterprise was frowned upon by the German Government; but, encouraged by German residents at Zanzibar, the three young pioneers crossed to the mainland, and on the 19th November, while the diplomatists assembled at Berlin were solemnly discussing the rules which were to govern the game of partition, the first "treaty" was signed at Mbuzini, and the German flag raised for the first time in East Africa.

In the period between 1875-84 Italy had also obtained her first footing on the African continent. By a treaty with the sultan of Assab, chief of the Danakils, signed on the 15th March 1883 and subsequently approved by the King of Shoa, Italy obtained the cession of part of Ablis (Aussa) on the Red Sea, Italy undertaking to protect with her fleet the Danakil littoral.

One other event of some importance must further be recorded as happening before the meeting of the Berlin Conference. The King of the Belgians had been driven to the conclusion that, if his African enterprise was to obtain any measure of permanent success, its international status must be recognized. To this end negotiations were opened with various Governments. The first Government to "recognize the flag of the International African Association as the flag of a friendly Government" was that of the United States, its declaration to that effect bearing date the 22nd April 1884. There were, however, difficulties in the way of obtaining the recognition of the European Powers, and in order to obtain that of France, and while labouring under the feelings of annoyance which had been aroused by the Anglo-Portuguese agreement concluded by Lord Granville in February, King Leopold, on the 23rd April 1884, authorized Colonel Strauch, president of the International Association, to engage to give France "the right of preference if, through unforeseen circumstances, the Association were compelled to sell its possessions." France's formal recognition of the Association as a Government was, however, delayed by the discussion of boundary questions until the following February, and in the meantime Germany, Great Britain, Italy, Austria-Hungary, Holland, and Spain had all recognized the Association; though Germany alone had done so—on 8th November—before the assembling of the conference.

The Berlin Conference.

The conference assembled at Berlin on 15th November 1884. Its last sitting was held on the 30th January 1885, and the "General Act of the Berlin Conference" was signed by the representatives of all the Powers attending the conference, except the United States, on the 24th February. The European Powers represented were Great Britain, Germany, Austria-Hungary, Belgium, Denmark, Spain, France, Italy, Holland, Portugal, Russia, Sweden and Norway, and Turkey, to name them in the order adopted in the preamble to the General Act. It is unnecessary to examine in detail the results of the labours of the conference. The General Act dealt with six specific subjects: (1) freedom of trade in the basin of the Congo, (2) the slave trade, (3) neutrality of territories in the basin of the Congo, (4) navigation of the Congo, (5) navigation of the Niger, (6) rules for future occupation on the coasts of the African continent. It will be seen that the Act dealt with other matters than the political partition of Africa; but, so far as they concern our present purpose, the results effected by the Berlin Act may be summed up as follows. The signatory Powers undertook that any fresh act of taking possession on any portion of the African coast must be notified by the Power taking possession, or assuming a protectorate, to the other signatory Powers. It was further provided that any such occupation to be valid must be effective. It is also noteworthy that the first reference in an international Act of the obligations attaching to "spheres of influence" is contained in the Berlin Act.

The Congo Free State.

The basin of the Congo was defined as "bounded by the watersheds (or mountain ridges) of the adjacent basins, namely, in particular those of the Niari, the Ogowé, the Shari, and the Nile on the north; by the eastern watershed line of the affluents of Lake Tanganyika on the east; and by the watersheds of the basins of the Zambezi and the Logé on the south. It therefore comprises all the regions watered by the Congo and its affluents, including Lake Tanganyika, with its eastern tributaries." In this conventional basin of the Congo the trade of all nations was to enjoy complete freedom. But the free-trade zone was extended considerably beyond the Congo basin. It comprised on the east coast the maritime zone, extended from 2° 30′ of S. lat. to the mouth of the Logé. The northern boundary of the free-trade zone followed the parallel of 2° 30′ to the geographical basin of the Congo, and thence to the east coast at 5° N. lat., the eastern boundary following the coast southwards to the mouth of the Zambezi; from this latter point the southern boundary followed the Zambezi to 5 miles above its confluence with the Shiré, and thence along the Nyasa-Zambezi watershed to the Congo-Zambezi watershed and the source of the Logé, which it followed to the coast. The approval of independent sovereign states in the eastern zone, which were not parties to the convention, was, however, to be obtained as a condition precedent to the extension of free trade to the eastern zone. The Act contained provisions limiting the dues to be levied within the prescribed area to such as "may be levied as fair compensation for expenditure in the interests of trade," prohibiting the imposition of preferential duties, and declaring the river free to the trading flags of all nations. The conventional basin of the Congo was to remain neutral in all circumstances, and an international navigation commission of the Congo was to be instituted to supervise the carrying out of the principles proclaimed in the General Act on that river and its affluents. No such commission was, however, in fact appointed. The navigation of the Niger and all its affluents was declared free to the merchant vessels of all nations, and Great Britain and France severally undertook to extend protection to traders of other nationalities in those portions of the river which were under their sovereignty or protection.

It will be remembered that when the conference assembled the International Association of the Congo had only been recognized as a sovereign state by the United States and Germany. But King Leopold and his agents had taken full advantage of the opportunity which the conference afforded, and before the General Act was signed the Association had been recognized by all the signatory Powers, with the not very important exception of Turkey, and the fact communicated to the conference by Colonel Strauch. It was not, however, until two months later, in April 1885, that King Leopold, with the sanction of the Belgian legislature, formally assumed the headship of the new state; and on the 1st August in the same year His Majesty notified the Powers that from that date the "Independent State of the Congo" declared that "it shall be perpetually neutral" in conformity with Article X. of the Berlin Act. Thus was finally constituted the Congo Free State, under the sovereignty of King Leopold, though the boundaries claimed for it at that time were considerably modified by subsequent agreements.

Developments since 1885.

From 1885 the scramble among the Powers went on with renewed vigour, and in the fifteen years that remained of the century the work of partition, so far as international agreements were concerned, was practically completed. To attempt to follow the process of acquisition year by year would involve a constant shifting of attention from one part of the continent to another, inasmuch as the scramble was proceeding simultaneously all over Africa. It will therefore be the most convenient plan to deal with the continent in sections, roughly corresponding to the quarters of the compass, with the Congo Free State as a sort of central state, the growth of which may serve as the starting-point for the story of the partition after the Berlin Conference. In the notification to the Powers of 1st August 1885, the boundaries of the Free State were set out in considerable detail. The limits thus determined resulted partly from agreements made with France and Portugal, and partly from treaties with native chiefs, and left the northern bank of the Congo to a point a little above Manyanga to the Free State, and the southern bank as far as Nokki to Portugal. The southern frontier was continued along the parallel of Nokki till it intersected the river Kwango, which it followed in a southernly direction. The northern frontier from Manyanga followed the Congo as far as Stanley Pool, then the median line of that pool, leaving the Congo at a point above the Likona-Nkunja river, following its watershed to the 17th degree of longitude east of Greenwich, which degree it followed until its intersection with the 4th parallel of N. latitude, following that latitude until it met the 30th degree of longitude east of Greenwich, which formed the eastern boundary of the Free State. The south-eastern frontier claimed by King Leopold extended to Lakes Tanganyika, Mweru, and Bangweulu, but it was not until some years later that it was recognized and defined by the agreement of May 1894 with Great Britain. The international character of King Leopold's enterprise had not long been maintained, and his recognition as sovereign of the Free State confirmed the distinctively Belgian character which the Association had assumed, even before that event. The king was naturally anxious that the right of pre-emption which he had given to France should not operate against Belgium, and in April 1887 the French Government, in return for territorial concessions on the Mobangi, formally declared that France's right of pre-emption could not be opposed to Belgium's preferential rights; and by his will, dated 2nd August 1889, His Majesty made Belgium heir to the sovereign rights of the Congo Free State. In July 1890 the Free State concluded an agreement with Belgium, by which the Belgian Government agreed to make a loan to the Free State of twenty-five millions of francs, spread over ten years, Belgium acquiring the right within six months after the expiry of that period to annex the Free State. To complete this section of the subject, it may be stated that an annexation Bill, introduced into the Belgian parliament in 1895, was withdrawn, and up to June 1901 Belgium had still taken no formal steps to assume direct responsibility for the Free State as a Belgian colony.

Aims of the Powers.

The area of the Free State, vast as it was, did not suffice to satisfy the ambition of its sovereign. King Leopold maintained that the Free State enjoyed, equally with any other state, the right to extend its frontiers. As this ambition brought the Free State into sharp conflict with its various European neighbours, it may be well to consider, in the light of subsequent events, what were at this period the designs entertained by the different European Powers that participated in the struggle for Africa. Portugal was striving to retain as large a share as possible of her shadowy empire, and particularly to establish her claims to the Zambezi region, so as to secure a belt of territory across Africa from Mozambique to Angola. Great Britain, once aroused to the imminence of the danger, put forth vigorous efforts in East Africa and on the Niger, but her most ambitious dream was the establishment of an unbroken line of British possessions and spheres of influence from south to north of the continent, from Cape Colony to Egypt. Germany's ambition can be easily described. It was to secure as much as possible, so as to make up for lost opportunities. French ambitions, apart from Madagascar, were confined to the northern and central portions of the continent. To extend her possessions on the Mediterranean littoral, and to connect them with her colonies in West Africa, the Western Sudan, and on the Congo, by establishing her influence over the vast intermediate regions, was France's first ambition. But the defeat of the Italians in Abyssinia, and the impending downfall of the Khalifa's power in the valley of the Upper Nile, suggested a still more daring project to the French Government—none other than the establishment of French influence over a broad belt of territory stretching across the continent from west to east, from Senegal on the Atlantic coast to Jibutil on the Gulf of Aden. These conflicting ambitions could not all be realized, and Germany succeeded in preventing Great Britain from realizing her ambition of a continuous band of British territory from south to north, while Great Britain, by excluding France from the Upper Nile valley, dispelled the French dream of an empire from west to east.

King Leopold and the Nile.

It was in the struggle between France and Great Britain for the Upper Nile valley that the ambition of King Leopold involved the Congo Free State. The Egyptian Sudan, after the death of Gordon in January 1885, was abandoned to the Mahdi. The Egyptian frontier was withdrawn to Wady-Halfa, and the vast provinces of Kordofan, Darfur, and the Bahr-el-Ghazal were given over to Dervish tyranny and misrule. But it was obvious that this was not a state of things which could continue indefinitely. Under the wise guidance of Lord Cromer the finances of Egypt had been placed on a sound basis, and under British officers the despised fellaheen had developed soldierly qualities of which they had before given no sign. That Egypt would seek to recover her position in the Sudan was a foregone conclusion, as the command of the Upper Nile was recognized as essential to her continued prosperity. But the international position of the abandoned provinces was by no means clear. The British Government, by the Anglo-German agreement of July 1890, had secured the assent of Germany to the proposition that the British sphere of influence in East Africa was bounded on the west by the Congo Free State and by "the western watershed of the basin of the Upper Nile"; but this claim was not recognized either by France or by the Congo Free State. From her base on the Congo, France was busily engaged pushing forward along the northern tributaries of the great river. On 27th April 1887 an agreement was signed with the Congo Free State by which the right bank of the Mobangi river was secured to French influence, and the left bank to the Congo Free State, with this proviso, that the northern boundary of the Free State was not to descend below the fourth parallel of north latitude. The desire of France to secure a footing in the Upper Nile valley was partly due, as we have seen, to her anxiety to extend a French zone across Africa, but it was also and to a large extent attributable to the belief, widely entertained in France, that by establishing herself on the Upper Nile France could regain the position in Egyptian affairs which she had sacrificed in 1882. With these strong inducements France set steadily to work to consolidate her position on the tributary streams of the Upper Congo basin, preparatory to crossing into the valley of the Upper Nile. As a step in this direction the Mobangi region was constituted a separate province, under M. Liotard as governor. Meanwhile a similar advance was being made from the Congo Free State northwards and eastwards. King Leopold had two objects in view—to obtain control of the rich province of the Bahr-el-Ghazal and to secure an outlet on the Nile. Stations were established on the Welle river, and in February 1891, Captain van Kerckhoven left Leopoldville for the Upper Welle with the most powerful expedition which had, up to that time, been organized by the Free State. After some heavy fighting the expedition reached the Nile in September 1892, and opened up communications with the remains of the old Egyptian garrison at Wadelai. Other expeditions under Belgian officers penetrated into the Bahr-el-Ghazal, and it was apparent that King Leopold proposed to rely on effective occupation as an answer to any claims which might be advanced by either Great Britain or France. The news of what was happening in this remote region of Africa filtered through to Europe very slowly, but King Leopold was warned on several occasions that Great Britain would not recognize any claims by the Congo Free State on the Bahr-el-Ghazal. The difficulty was, however, that neither from Egypt, whence the road was barred by the Khalifa, nor from Uganda, which was too far removed from the coast to serve as the base of a large expedition, could a British force be despatched to take effective occupation of the Upper Nile valley. There was, therefore, danger lest the French should succeed in establishing themselves on the Upper Nile before the preparations which were being made in Egypt for "smashing" the Khalifa were completed.

The Anglo-Congolese Agreement of 1894.

In these circumstances Lord Rosebery, who was then foreign minister, began, and his successor, Lord Kimberley, completed, negotiations with King Leopold which resulted in the conclusion of the Anglo-Congolese agreement of 12th May 1894. By this agreement King Leopold recognized the British sphere of influence as laid down in the Anglo-German agreement of July 1890, and Great Britain granted a lease to King Leopold of certain territories in the western basin of the Upper Nile, extending on the Nile from a point on Lake Albert to Fashoda, and westwards to the Congo-Nile watershed. The practical effect of this agreement was to give the Congo Free State a lease, during its sovereign's lifetime, of the old Bahr-el-Ghazal province, and to secure after His Majesty's death a portion of that territory, with access to a port on Lake Albert, to his successor. At the same time the Congo Free State leased to Great Britain a strip of territory, 15½ miles in breadth, between the north end of Lake Tanganyika and the south end of Lake Albert Edward. This agreement was hailed as a notable triumph for British diplomacy. But the triumph was short-lived. By the agreement of July 1890 with Germany, Great Britain had been reluctantly compelled to abandon her hopes of through communication between the British spheres in the northern and southern parts of the continent, and to consent to the boundary of German East Africa marching with the eastern frontier of the Congo Free State. Germany frankly avowed that she did not wish to have a powerful neighbour interposed between herself and the Congo Free State, and later troubles as to frontiers in the Lake Kivu region fully justified the attitude of the German Government. It was obvious that the new agreement would effect precisely what Germany had declined to agree to in 1890. Accordingly Germany protested in such vigorous terms that, on the 22nd June 1894, the offending article was withdrawn by an exchange of notes between Great Britain and the Congo Free State. Opinion in France was equally excited by the new agreement. It was obvious that the lease to the Congo Free State was intended to exclude France from the Nile by placing the Congo Free State as a barrier across her path. Pressure was brought to bear on King Leopold, from Paris, to renounce the rights acquired under the agreement. It is not known what communications, if any, passed between the sovereign of the Free State and the British Government, whether King Leopold asked for, or was refused, support against French pressure; but on the 14th August 1894 King Leopold signed an agreement with France by which, in exchange for France's acknowledgment of the Mbomu river as his northern frontier, His Majesty renounced all occupation and all exercise of political influence west of 30° E. longitude, and north of a line drawn from the intersection of that meridian with the parallel 5° 30′ of N. latitude, and along that parallel to the Nile.

France and the Bahr-el-Ghazal.

This left the way still open for France to the Nile, and in June 1896 Captain Marchand left France with secret instructions to lead an expedition into the Nile valley. On the 1st of March in the following year he left Brazzaville, and began a journey which all but plunged Great Britain and France into war. The difficulties which Captain Marchand had to overcome were mainly those connected with transport. In October 1897 the expedition reached the banks of the Sueh, the waters of which eventually flow into the Nile. Here a post was established and the *Faidherbe*, a steamer which had been carried across the Congo-Nile watershed in sections, was put together and launched. On the 1st May 1898 Marchand started on the final stage of his journey, and reached Fashoda on the 10th July, having established a chain of posts *en route*. At Fashoda the French flag was at once raised, and a "treaty" made with the local chief. Meanwhile other expeditions had been concentrating on Fashoda—a mud-flat situated in a swamp, round which for many months raged the angry passions of two great peoples. French expeditions, with a certain amount of assistance from the Emperor Menelek of Abyssinia, had been striving to reach the Nile from the east, so as to join hands with Marchand and complete the line of posts to the Abyssinian frontier. In this, however, they were unsuccessful. No better success attended the expedition under Colonel Macdonald, R.E., sent by the British Government from Uganda to anticipate the French in the occupation of the Upper Nile. It was from the north that claimants arrived to dispute with the French their right to Fashoda, and all that the occupation of that dismal post implied. In 1897 an Anglo-Egyptian army, under the direction of Sir Herbert (afterwards Lord) Kitchener, had begun to advance southwards for the reconquest of the Egyptian Sudan. On the 2nd September 1898 Khartum was captured, and the Khalifa's army dispersed. It was then that news reached the Anglo-Egyptian commander, from native sources, that there were white men flying a strange flag at Fashoda. The Sirdar at once proceeded in a steamer up the Nile, and courteously but firmly requested Captain Marchand to remove the French flag. On his refusal the Anglo-Egyptian flag was raised close to the French flag, and the dispute was referred to Europe for adjustment. Diplomatic negotiations followed between the British and French Governments. At length, on 21st March 1899, a declaration was signed, by the terms of which France withdrew from the Nile valley and accepted a boundary line, between the British and French spheres of influence in Central Africa, which satisfied her earlier ambition by uniting the whole of her territories in North, West and Central Africa into a homogeneous whole, while effectually preventing the realization of her dream of a transcontinental empire from west to east. By this declaration it was agreed that the dividing line between the British and French spheres, north of the Congo Free State, should follow the Congo-Nile water-parting up to its intersection with the 11th parallel of north latitude, from which point it was to be "drawn as far as the 15th parallel in such a manner as to separate in principle the kingdom of Wadai from what constituted in 1882 the province of Darfur," but in no case was it to be drawn west of the 21st degree of east longitude, or east of the 23rd degree. From the 15th parallel the line took a north-westerly direction, until it intersected the Tropic of Cancer, on the southern frontier of the Turkish province of Fezzan to the south of Tripoli. French influence was to prevail west of this line, British influence to the east. Wadai was thus definitely assigned to France. This partition was and still is (1901) merely a paper partition; and it should be added that while it, of course, only binds the parties to it, the Sultan of Turkey entered a protest against the agreement as infringing his prior acquired rights both in the Sahara and in the Central Sudan.

Portugal in South-West and South-East Africa.

Let us now return to the mouth of the Congo and see what was the course of events in the southern half of the continent. It will be remembered that by the agreement in which Portugal recognized the sovereignty of the Congo Free State, Portugal's claim to the southern bank of the river as far as Nokki had been admitted. Thus Portuguese possessions on the west coast extended from the Congo to the mouth of the Kunene river. In the interior the boundary with the Free State was settled as far as the Kwango river, but disputes arose as to the right to the country of Lunda, otherwise known as the territory of the Muato Yanvo. On the 25th May 1891 a treaty was signed at Lisbon, by which this large territory was divided between Portugal and the Free State, the boundary line leaving the Kwango at the 8th degree of south latitude and reaching the Kasai, one of the main southern affluents of the Congo, at the 7th degree, then passing along the *thalweg* of that river to its source in Lake Dilolo, and then along the watershed between the Zaire and the Zambezi to its intersection by the 24th meridian east of Greenwich. The interior limits of Portuguese possessions in Africa south of the equator gave rise, however, to much more serious discussions than were involved in the dispute as to the Muato Yanvo's kingdom. Portugal, as we have seen, claimed all the territories between Angola and Mozambique, and she succeeded in inducing both France and Germany, in 1886, to recognize the King of Portugal's "right to exercise his sovereign and civilizing influence in the territories which separate the Portuguese possessions of Angola and Mozambique." The publication of the treaties containing this declaration, together with a map showing Portuguese claims extending over the whole of the Zambezi valley, and over Matabeleland to the south and the greater part of Lake Nyasa to the north, immediately provoked a formal protest from the British Government. On the 13th August 1887, the British Chargé d'Affaires at Lisbon transmitted to the Portuguese minister for foreign affairs a memorandum from Lord Salisbury, in which the latter formally protested "against any claims not founded on occupation" and contended that the doctrine of effective occupation had been admitted in principle by all the parties to the Act of Berlin. Lord Salisbury further stated that "Her Majesty's Government cannot recognize Portuguese sovereignty in territory not occupied by her in sufficient strength to enable her to maintain order, protect foreigners, and control the natives." To this Portugal replied that the doctrine of effective occupation was expressly confined by the Berlin Act to the African coast, but at the same time expeditions were hastily despatched up the Zambezi and some of its tributaries to discover traces of former Portuguese occupation. Matabeleland and the districts of Lake Nyasa were specially mentioned in the British protest as countries in which Her Majesty's Government took a special interest. As a matter of fact the extension of British influence northwards to the Zambezi had engaged the attention of the British authorities, ever since the appearance of Germany in South-West Africa and the declaration of a protectorate over Bechuanaland. There were rumours of German activity in Matabeleland, and of a Boer trek north of the Limpopo. Hunters and explorers had reported in eulogistic terms on the rich goldfields and healthy plateau lands of Matabeleland and Mashonaland, over both of which countries a powerful native chief, Lobengula, son of the great Moziligazi, claimed authority. The Matabele, or Amandebele, were a branch of the great Zulu family and a race of warriors. There were many suitors for Lobengula's favours; but on the 11th February 1888 he signed a treaty with Mr J. S. Moffat, the assistant commissioner in Bechuanaland, the effect of which was to place all his territory under British protection. Both the Portuguese and the Transvaal Boers were naturally chagrined at this extension of British influence. A number of Boers attempted unsuccessfully to trek into the country, and Portugal opposed her ancient claims to the new treaty. She contended that Lobengula's authority did not extend over Mashonaland, which she claimed as part of the Portuguese province of Sofala, and suddenly developed spasmodic activity in the distribution of flags and the establishment of stations and forts, not only in Eastern Mashonaland, but in the countries north of the Zambezi. Meanwhile preparations were being actively made for the exploitation of the mineral and other resources of Lobengula's territories. Two rival syndicates obtained, or claimed to have obtained, concessions from Lobengula; but in the summer of 1889 Mr Cecil Rhodes succeeded in amalgamating the conflicting interests, and on the 29th October of that year Her Majesty granted a charter to the British South Africa Company (see CHARTERED COMPANIES), the grantees being the Duke of Abercorn, the Duke of Fife, Lord Gifford, Mr Cecil J. Rhodes, Mr Albert Beit, Mr Albert Grey, and Mr George Cawston. The first article of the charter declared that "the principal field of the operations" of the company "shall be the region of South Africa lying immediately to the north of British Bechuanaland, and to the north and west of the South African Republic, and to the west of the Portuguese dominions." No time was lost in making preparations for effective occupation. On the advice of Mr F. C. Selous it was determined to despatch an expedition to Eastern Mashonaland by a new route, which would avoid the Matabele country. This plan was carried out in the summer of 1890, and, thanks to the rapidity with which the column moved and Mr Selous's intimate knowledge of the country, the British flag was, on 11th September, hoisted at a spot on the Makubusi river, where the town of Salisbury now stands, and the country taken possession of in the name of Queen Victoria. Disputes with the Portuguese ensued, and there were several frontier incidents which for a time embittered the relations between the two countries.

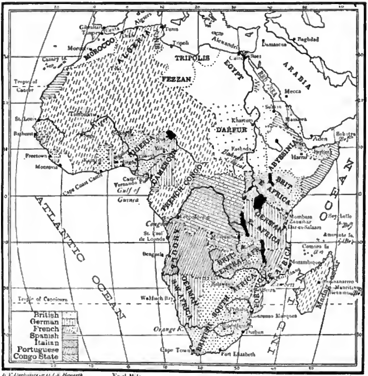
Matabeleland and Mashonaland.

Britain and Portugal north of the Zambezi.

Meanwhile, north of the Zambezi, the Portuguese were making desperate but futile attempts to repair the neglect of centuries by hastily-organized expeditions and the hoisting of flags. In 1888 an attempt to close the Zambezi to British vessels was frustrated by the firmness of Lord Salisbury. In a despatch to the British minister at Lisbon, dated 25th June 1888, Lord Salisbury, after brushing aside the Portuguese claims founded on doubtful discoveries three centuries old, stated the British case in a few sentences. "It is," he wrote, "an undisputed point that the recent discoveries of the English traveller, Livingstone, were followed by organized attempts on the part of English religious and commercial bodies to open up and civilize the districts surrounding and adjoining the lake. Many British settlements have been established, the access to which from the sea is by the rivers Zambezi and Shiré. Her Majesty's Government and the British public are much interested in the welfare of these settlements. Portugal does not occupy, and has never occupied, any portion of the lake, nor of the Shiré; she has neither authority nor influence beyond the confluence of the Shiré and Zambezi, where her interior custom house, now withdrawn, was placed by the terms of the Mozambique Tariff of 1877." As a matter of historical accuracy it may be well to add that the Nyasa region has, from the first, been peculiarly associated with Scottish enterprise. Apart from the fact that Livingstone was a Scotsman, the first missions were established by the Scottish churches, the first planters were Scottish, and the "African Lakes Company," which was the pioneer in trading and transport operations, was a Scottish corporation. In 1889 it became known to the British Government that a considerable Portuguese expedition was being organized for operating in the Zambezi region. In answer to inquiries addressed to the Portuguese Government, the foreign minister stated that the object of the Serpa Pinto expedition was to visit the Portuguese settlements on the Upper Zambezi. The British Government was, even so late as 1889, averse from declaring a formal protectorate over the Nyasa region; but early in that year Mr H. H. (afterwards Sir Harry) Johnston was sent out to Mozambique as British consul, with instructions to travel in the interior and report on the troubles that had arisen with the Arabs on Lake Nyasa and with the Portuguese. The discovery of a navigable mouth of the Zambezi—the Chinde—and the offer by Mr Rhodes of a subsidy of £10,000 a year from the British South Africa Company, removed some of the objections to a protectorate entertained by the British Government; but Mr Johnston's instructions were not to proclaim a protectorate unless circumstances compelled him to take that course. To his surprise, Mr Johnston learnt on his arrival at the Zambezi that Major Serpa Pinto's expedition had been suddenly deflected to the north. Hurrying forward, Mr Johnston overtook the Portuguese expedition and warned its leader that any attempt to establish political influence north of the Ruo river would compel him to take steps to protect British interests. On arrival at the Ruo, Major Serpa Pinto returned to Mozambique for instructions, and in his absence Lieutenant Coutinho crossed the river, attacked the Makalolo chiefs, and sought to obtain possession of the Shiré highlands by a *coup de main*. Mr Buchanan, the British vice-consul, lost no time in declaring the country under British protection, and his action was subsequently confirmed by Mr Johnston on his return from a treaty-making expedition on Lake Nyasa. On the news of these events reaching Europe the British

Government addressed an ultimatum to Portugal, as the result of which Lieutenant Coutinho's action was disavowed, and he was ordered to withdraw the Portuguese forces south of the Ruo. But while Mr Johnston was busily engaged in concluding treaties with the native chiefs in the districts to which Portugal had no prior claim, the diplomatists in Europe were seeking for a solution of the troubles which had arisen both north and south of the Zambezi. As the result of prolonged negotiations, an agreement was signed between Great Britain and Portugal on the 20th August 1890, by which Great Britain obtained a broad belt of territory north of the Zambezi, stretching from Lake Nyasa on the east, the southern end of Tanganyika on the north, and Lake Bangweulu on the west; while south of the Zambezi Portugal was allowed to retain the right bank of the river from a point ten miles above Zumbo, and the eastern boundary of her territory south of the river was made roughly to coincide with the 33rd degree of east longitude. The publication of the agreement aroused deep resentment in Portugal, and the Government, unable to obtain its ratification by the Chamber of Deputies, resigned. In October the abandonment of the treaty was accepted by the new Portuguese ministry as a *fait accompli*; but on the 14th November the two Governments signed an agreement for a *modus vivendi*, by which they engaged to recognize the territorial limits indicated in the convention of 20th August "in so far that from the date of the present agreement to the termination thereof neither Power will make treaties, accept protectorates, nor exercise any act of sovereignty within the spheres of influence assigned to the other party by the said convention." The breathing-space thus gained enabled feeling in Portugal to cool down, and on the 11th June 1891 another treaty was signed, the ratifications being exchanged on the 3rd July. This is the main treaty, defining the British and Portuguese spheres both south and north of the Zambezi. It contained many other provisions relating to trade and navigation, providing *inter alia* a maximum transit duty of 3 per cent. on imports and exports crossing Portuguese territories on the east coast to the British sphere, freedom of navigation of the Zambezi and Shiré for the ships of all nations, and stipulations as to the making of railways, roads, and telegraphs. The territorial readjustment effected left Portugal a triangular strip of territory north of the Zambezi, with its base on the Zambezi-Shiré watershed and its apex on the angle formed by the Zambezi and the Loangwa, close to Zumbo. South of the Zambezi the Portuguese frontier, after running for a short distance due south, takes an east-south-easterly direction to the Mazoe river, which it intersects at the 33rd degree of east longitude and follows that meridian to its intersection by the 18° 30′ parallel of south latitude, whence it follows the eastern slope of the Manica plateau southwards to the centre of the main channel of the Sabi, follows that

The treaty of 1891.



SKETCH MAP ILLUSTRATING THE PARTITION OF AFRICA.

channel to its confluence with the Lunte, whence it strikes directly to the north-eastern point of the frontier of the Transvaal, and follows the eastern frontier of that territory and the frontier of Swaziland to the river Maputa. The delimitation of this frontier was not accomplished without considerable difficulty and a recourse to arbitration. Some parts of the boundary north of the Zambezi were not delimited until the closing months of the 19th century. The western boundary between the British and Portuguese spheres of influence was only vaguely indicated, and had not been settled in 1900 by the Anglo-Portuguese Commission; but it was to be drawn in such a manner as to leave the Barotse country within the British sphere, Lewanika, the paramount chief of the Marotse, claiming that his territory extended much farther to the west than was admitted by the Portuguese.

British Central Africa.

Before the conclusion of the treaty of June 1891 with Portugal, the British Government had made certain arrangements for the administration of the large area north of the Zambezi reserved to British influence. On the 1st of February Mr H. H. Johnston was appointed Imperial Commissioner in Nyasaland, and a fortnight later the British South Africa Company intimated a desire to extend its operations north of the Zambezi. Negotiations followed, and the field of operations of the Chartered Company was, on the 2nd April 1891, extended so as to cover the whole of the British sphere of influence north of the Zambezi, with the exception of Nyasaland, the Company agreeing to appoint Mr Johnston political Administrator of its territories north of the Zambezi, now known as Northern Rhodesia, and to contribute £10,000 a year towards the cost of administration, to be applied by Mr Johnston at his discretion either in Nyasaland or in the Company's sphere. On the 14th of May a formal protectorate was declared over Nyasaland, including the Shiré highlands and a wide belt of territory from the Anglo-German frontier on the north end of Lake Nyasa along the western shore of the lake. The name was subsequently changed to the British Central Africa Protectorate (*q.v.*). The arrangement as to the joint administration of the Protectorate and the Company's sphere lasted for some three years, and at the end of that time the Company appointed a separate administration for Northern Rhodesia, and the subsidy was withdrawn.

German South-West Africa.

At the date of the assembling of the Berlin Conference the German Government had notified that the coast-line on the south-west of the continent, from the Orange river to Cape Frio, had been placed under German protection. On the 13th April 1885 the German South-West Africa Company was constituted under an order of the Imperial Cabinet with the rights of state sovereignty, including mining royalties and rights, and a railway and telegraph monopoly. In that and the following years the Germans vigorously pursued the business of treaty-making with the native chiefs in the interior; and when, in July 1890, the British and German Governments came to an agreement as to the limits of their respective spheres of influence in various parts of Africa, the boundaries of German South-West Africa were fixed in their present position. By Article III. of this important agreement the north bank of the Orange river up to the point of its intersection by the 20th degree of east longitude was made the southern boundary of the German sphere of influence. The eastern boundary followed the 20th degree of east longitude to its intersection by the 22nd parallel of south latitude, then ran eastwards along that parallel to the point of its intersection by the 21st degree of east longitude. From that point it ran northwards along the last-named meridian to the point of its intersection by the 18th parallel of south latitude, thence eastwards along that parallel to the river Chobe, and along the main channel of that river to its junction with the Zambezi, where it terminated. The northern frontier marched with the southern boundary of Portuguese West Africa. The object of deflecting the eastern boundary near its northern termination was to give Germany access by her own territory to the upper waters of the Zambezi, and it was declared that this strip of territory was at no part to be less than twenty English miles in width.

British South Africa.

To complete the survey of the political partition of Africa south of the Zambezi, it is necessary briefly to refer to the events connected with the South African Republic and the Orange Free State. In October 1886 the British Government made an agreement with the New Republic, a small community of Boer farmers who had set up a Government of their own, defining the frontier between the New Republic and Zululand; but less than a year later—in September 1887—the New Republic was incorporated in the South African Republic. In a convention of July–August 1890 the British Government and the Government of the South African Republic confirmed the independence of Swaziland, and on the 8th November 1893 another convention was signed with the same object; but on the 19th December 1894 the British Government agreed to the South African Republic exercising "all rights and powers of protection, legislation, jurisdiction, and administration over Swaziland and the inhabitants thereof," subject to certain conditions and provisions, and to the non-incorporation of Swaziland in the Republic. Subsequently, on the 23rd April 1895, Tongaland was declared by proclamation to be added to the dominions of Queen Victoria, and in December 1897 Zululand and Tongaland, or Amatongaland, were incorporated with the colony of Natal. The history of the events that led up to the last Boer war cannot be recounted here (see TRANSVAAL COLONY and ORANGE RIVER COLONY), but in October 1899 the South African Republic and the Orange Free State addressed an ultimatum to Great Britain and invaded Natal and Cape Colony. As a result of the military operations that followed, the Orange Free State was, on 28th May 1900, proclaimed by Lord Roberts a British colony under the name "Orange River Colony," and the South African Republic was on the 25th October 1900 incorporated in the British Empire as the "Transvaal Colony."

Germany and Great Britain in East Africa.

On the east coast the two great rivals were Germany and Great Britain. Germany on the 30th December 1896, and Great Britain on the 11th June 1891, formally recognized the Rovuma river as the northern boundary of the Portuguese sphere of influence on that coast; but it was to the north of that river, over the vast area of East or East Central Africa in which the Sultan of Zanzibar claimed to exercise suzerainty, that the struggle between the two rival Powers was most acute. The independence of the Sultans of Zanzibar had been recognized by the Governments of Great Britain and France in 1862, and the Sultan's authority extended almost uninterruptedly along the coast of the mainland, from Cape Delgado in the south to Warshekh on the north—a stretch of coast more than a thousand miles long—though to the north the Sultan's authority was confined to certain ports. In Zanzibar itself, where Sir John Kirk, Livingstone's companion, was British consul-general, British influence was, when the Berlin Conference met, practically supreme, though German traders had established themselves on the island and created considerable commercial interests. Away from the coasts the limits and extent of the Sultan's authority were far from being clearly defined. The Sultan himself claimed that it extended as far as Lake Tanganyika, but the claim did not rest on any very solid ground of effective occupation. The little-known region of the Great Lakes had for some time attracted the attention of the men who were directing the colonial movement in Germany; and, as we have seen, a small band of pioneers actually landed on the mainland opposite Zanzibar in November 1884, and made their first "treaty" with the chief of Mbuzini on the 19th of that month. Pushing up the Wami river the three adventurers reached the Usagara country, and concluded more "treaties," the net result being that when, in the middle of December, Dr Peters returned to the coast he brought back with him documents which were claimed to concede some 60,000 square miles of country to the German Colonization Society. Dr Peters hurried back to Berlin, and on the 17th of February 1885 the German Emperor issued a "Charter of Protection" by which His Majesty accepted the suzerainty of the newly-acquired territory, and "placed under our Imperial protection the territories in question." The conclusion of these treaties was, on the 6th March, notified to the British Government and to the Sultan of Zanzibar. Immediately on receipt of the notification the Sultan telegraphed an energetic protest to Berlin, alleging that the places placed under German protection had belonged to the Sultanate of Zanzibar from the time of his fathers. The German consul-general refused to admit the Sultan's claims, and meanwhile agents of the German society were energetically pursuing the task of treaty-making. The Sultan despatched a small force to the disputed territory, which was subsequently withdrawn, and in May sent a more imposing expedition under the command of General Mathews, the commander-in-chief of the Zanzibar army, to the Kilimanjaro district, in order to anticipate the German agents who were reported to be hastening to conclude treaties with the chiefs of Chagga and Taveta. Meanwhile Lord Granville, who was then at the Foreign Office, had taken up an extremely friendly attitude towards the German claims. Prior to these events the Sultan of Zanzibar had, on more than one occasion, practically invited Great Britain to assume a protectorate over his dominions. But the invitations had been declined. Egyptian affairs were, in the year 1885, causing considerable anxiety to the British Government, and the fact may not have been without influence on the attitude of the British foreign secretary. On the 25th May 1885, in a despatch to the British ambassador at Berlin, Lord Granville instructed Sir E. Malet to communicate the views of the British Cabinet to Prince Bismarck:—

> I have to request your Excellency to state that the supposition that Her Majesty's Government have no intention of opposing the German scheme of colonization in the neighbourhood of Zanzibar is absolutely correct. Her Majesty's Government, on the contrary, view with favour these schemes, the realization of which will entail the civilization of large tracts over which hitherto no European influence has been exercised, the co-operation of Germany with Great Britain in the work of the suppression of the slave gangs, and the encouragement of the efforts of the Sultan both in the extinction of the slave trade and in the commercial development of his dominions.

In the same despatch Lord Granville instructed Sir E. Malet to intimate to the German Government that some prominent capitalists had originated a plan for a British settlement in the country between the coast and the lakes, which are the sources of the White Nile, "and for its connexion with the coast by a railway." But Her Majesty's Government would not accord to these prominent capitalists the support they had called for, "unless they were fully satisfied that every precaution was taken to ensure that it should in no way conflict with the interests of the territory that has been taken under German protectorate," and Prince Bismarck was practically invited to say whether British capitalists were or were not to receive the protection of the British Government. The reference in Lord Granville's despatch was to a proposal made by a number of British merchants and others who had long been interested in Zanzibar, and who saw in the rapid advance of Germany a menace to the interests which had hitherto been regarded as paramount in the Sultanate. In 1884 Mr H. H. Johnston had concluded treaties with the chief of Taveta, and had transferred these treaties to Mr John Hutton of Manchester. Mr Hutton, with Mr (afterwards Sir William) Mackinnon, was one of the founders of what subsequently became the Imperial British East Africa Company. But in the early stages the champions of British interests in East Africa received no support from their own Government, while Germany was pushing her advantage with the energy of a recent convert to colonial expansion, and had even, on the coast, opened negotiations with the Sultan of Witu, a small territory situated north of the Tana river, whose ruler claimed to be independent of Zanzibar. On the 5th May 1885 the Sultan of Witu executed a deed of sale and cession to a German subject of certain tracts of land on the coast, and later in the same year other treaties or sales of territory were effected, by which German subjects acquired rights on the coast-line claimed by the Sultan. Inland, treaties had been concluded on behalf of Germany with the chiefs of the Kilimanjaro region, and an intimation to that effect made to the British Government. But before this occurred the German Government had succeeded in extracting an acknowledgment of the validity of the earlier treaties from the Sultan of Zanzibar. Early in August a powerful German squadron appeared off Zanzibar, and on the 14th of that month the Sultan yielded to the inevitable, acknowledged the German protectorate over Usagara and Witu, and undertook to withdraw his soldiers.

The Sultanate of Zanzibar.

Meanwhile negotiations had been opened for the appointment of an International Commission, "for the purpose of inquiring into the claims of the Sultans of Zanzibar to sovereignty over certain territories on the east coast of Africa, and of ascertaining their precise limits." The Governments to be represented were Great Britain, France, and Germany, and towards the end of 1885 commissioners were appointed. The commissioners reported on the 9th of June 1886, and assigned to the Sultan the islands of Zanzibar, Pemba, Lamu, Mafia, and a number of other small islands. On the mainland they recognized as belonging to the Sultan a continuous strip of territory, 10 sea miles in depth, from the south bank of the Minengani river, a stream a short distance south of the Rovuma, to Kipini, at the mouth of the Tana river, some 600 miles in length. North of Kipini the commissioners recognized as belonging to the Sultan the stations of Kismayu, Brava, Meurka, and Magadisho, with radii landwards of 10 sea miles, and of Warshekh with a radius of 5 sea miles. By an exchange of notes in October–November 1886 the Governments of Great Britain and Germany accepted the reports of the Delimitation Commissioners, to which the Sultan adhered on the 4th of the following December. But the British and German Governments did more than determine what territories were to be assigned to the Sultanate of Zanzibar. They agreed to a delimitation of their respective spheres of influence in East Africa. The territory to be affected by this arrangement was to be bounded on the south by the Rovuma river, "and on the north by a line which, starting from the mouth of the

Tana river, follows the course of that river or its affluents to the point of intersection of the equator and the 38th degree of east longitude, thence strikes direct to the point of intersection of the 1st degree of north latitude with the 37th degree of east longitude, where the line terminates." The line of demarcation between the British and the German spheres of influence was to start from the mouth of the river Wanga or Umba, to pass round the eastern and northern side of Lake Jipe, cross the Lumi river, pass between the territories of Taveta and Chagga, skirt the northern base of the Kilimanjaro range, and thence be drawn direct to the point on the eastern side of Victoria Nyanza which is intersected by the 1st degree of south latitude. South of this line German influence was to prevail; north of the line was the British sphere. The Sultan's dominions having been thus truncated, Germany associated herself with the recognition of the "independence" of Zanzibar in which France and Great Britain had joined in 1862. The effect of this agreement was to define the spheres of influence of the two countries as far as Victoria Nyanza, but it provided no limit to the westwards, and left the country north of the Tana river, in which Germany had already acquired some interests near the coast, open for fresh annexations. The conclusion of the agreement immediately stimulated the enterprise both of the German East Africa Association, to which Dr Peters's earlier treaties had been transferred, and of the British capitalists to whom reference had been made in Lord Granville's despatch. The German Association was incorporated by Imperial charter in March 1887, and the British capitalists formed themselves into the British East Africa Association, and on 24th May 1877 obtained, through the good offices of Sir William Mackinnon, a concession of the 10-miles strip of coast from the Umba river in the south to Kipini in the north. The Association was to have the entire administration of the territory for fifty years, and was to govern in the Sultan's name, on certain conditions as to the payment of the customs dues. The British Association further sought to extend its rights in the sphere reserved to British influence by making treaties with the native chiefs behind the coast strip, and for this purpose various expeditions were sent into the interior. When they had obtained concessions over the country for some 200 miles inland the associated capitalists applied to the British Government for a charter, which was granted on 3rd September 1888, and the Association became the Imperial British East Africa Company (see CHARTERED COMPANIES). The example set by the British company in obtaining a lease of the coast strip between the British sphere of influence and the sea was quickly followed by the German Association, which, on the 28th April 1888, concluded an agreement with the Sultan Khalifa, who had succeeded his brother Burghash, by which the Association leased the strip of Zanzibar territory between the German sphere and the sea. It was not, however, until August that the German officials took over the administration, and their want of tact and ignorance of native administration almost immediately provoked a rebellion, of so serious a character that it was not suppressed until the Imperial authorities had taken the matter in hand. Shortly after its suppression the administration was entrusted to an Imperial officer, and the Sultan's rights on the mainland strip were bought outright by Germany for four millions of marks.

Uganda.

Events of great importance had been happening, meanwhile, in the country to the west and north of the British sphere of influence. The British company had sent caravans into the interior to survey the country, to make treaties with the native chiefs, and to report on the commercial and agricultural possibilities. One of these had gone up the Tana river. But another and a rival expedition was proceeding along the northern bank of this same river. Dr Carl Peters, whose energy cannot be denied, whatever may be thought of his methods, set out with an armed caravan up the Tana on the pretext of leading an expedition to the relief of Emin Pasha, who was then reported to be hemmed in by the dervishes at Wadelai. His expedition was not sanctioned by the German Government, which was at that moment receiving material assistance from Great Britain in the suppression of the Bushiri rebellion, and the British naval commander had orders to prevent his landing. But Peters succeeded in evading the British vessels and proceeded up the river, planting German flags and fighting the natives who opposed his progress. Early in 1890 he reached Kavirondo, and there found letters from Mwanga, King of Uganda, addressed to Mr F. J. Jackson, the leader of an expedition sent out by the British East Africa Company, imploring the Company's representative to come to his assistance and offering to accept the British flag. To previous letters, less plainly couched, from the King, Mr Jackson had returned the answer that his instructions were not to enter Uganda, but that he would do so in case of need. The letters that fell into Peters's hands were in reply to those from Mr Jackson. Peters did not hesitate to open the letters, and on reading them he at once proceeded to Uganda, where, with the assistance of the French Roman Catholic priests, he succeeded in inducing Mwanga to sign a loosely-worded treaty intended to place him under German protection. On hearing of this Mr Jackson at once set out for Uganda, but Peters did not wait for his arrival, leaving for the south of Victoria Nyanza some days before Jackson arrived at Mengo, Mwanga's capital. For the complicated story of European relations with Uganda, reference must be made to the article on the UGANDA PROTECTORATE. It must be sufficient to say here that, as Mwanga would not agree to Mr Jackson's proposals, Mr Jackson returned to the coast, leaving Mr Gedge at Mengo to protect the Company's interests. Captain Lugard, who had recently entered the Company's employment, was at once ordered to proceed to Uganda. But in the meantime an event of great importance had taken place, the conclusion of an agreement between Great Britain and Germany with reference to their different spheres of influence in various parts of Africa.

Anglo-German agreement of 1890.

The Anglo-German agreement of 1st July 1890 has already been referred to in connexion with German South-West Africa. It was, however, of much greater importance in reference to East Africa. In return for the cession of Heligoland, Lord Salisbury obtained from Germany the recognition of a British protectorate over the dominions of the Sultan of Zanzibar, including the islands of Zanzibar and Pemba, but excluding the strip leased to Germany, which was subsequently ceded absolutely to Germany. Prince Bismarck further agreed to withdraw the protectorate declared over Witu and the adjoining coast up to Kismayu, in favour of Great Britain, and to recognize as within the British sphere of influence the vast area bounded, on the south by the frontier line laid down in the agreement of 1886, which was to be extended along the first parallel of south latitude across Victoria Nyanza to the frontiers of the Congo Free State; on the west by the Congo Free State and the western watershed of the Nile, and on the north by a line commencing on the coast at the north bank of the mouth of the river Juba, then ascending that bank of the river until it reached the territory reserved to the influence of Italy in Gallaland and Abyssinia, when it followed the frontier of the Italian sphere to the confines of Egypt. To the south-west of the German sphere in East Africa the boundary was formed by the eastern and northern shore of Lake Nyasa, and round the western shore to the mouth of the Songwe river, from which point it crossed the Nyasa-Tanganyika plateau to the southern end of the last-named lake, leaving the Stevenson Road on the British side of the boundary. The effect of this treaty was to remove all serious causes of dispute about territory between Germany and Great Britain in East Africa. It rendered quite valueless Dr Peters's treaty with Mwanga and his promenade along the Tana; it freed Great Britain from any fear of German competition to the northwards, and recognized that her influence extended to the western limits of the Nile valley. But, on the other hand, Great Britain had to relinquish the ambition of connecting her sphere of influence in the Nile valley with her possessions in the Nyasa-Tanganyika region. On this point Germany was quite obdurate; and, as we have already seen, an attempt subsequently made (May 1894) to secure this object by the lease of a strip of territory from the Congo Free State, was frustrated by German opposition.

Uganda having thus been assigned to the British sphere of influence by the only European Power in a position to contest its possession with her, the subsequent history of that region, and of the country between the Victoria Nyanza and the coast, must be traced in the articles on EAST AFRICA, BRITISH, and UGANDA, but it may be well briefly to record here the following facts:—The Imperial British East Africa Company, finding the burden of administration too heavy for its financial resources, and not receiving the assistance it felt itself entitled to receive from the Imperial authorities, intimated that it would be compelled to withdraw at the end of the year 1892. Funds were raised to enable the Company to continue its administration until the end of March 1893, and a strong public protest against evacuation compelled the Government to determine in favour of the retention of the country. In January 1893 Sir Gerald Portal left the coast as a special commissioner to inquire into the "best means of dealing with the country, whether through Zanzibar or otherwise." On the 31st March the Union Jack was raised, and on the 29th May a fresh treaty was concluded with King Mwanga, placing his country under British protection. A formal protectorate was declared over Uganda proper on 19th June 1894, which was subsequently extended so as to include the countries westwards towards the Congo Free State and eastwards to the British East Africa Protectorate. This latter protectorate was constituted in June 1895, when the Imperial British East Africa Company relinquished all its rights in exchange for a money payment, and the administration was assumed by the Imperial authorities.

Italy in East Africa.

In 1883 Italy had obtained her first formal footing on the African coast at the Bay of Assab (Aussa) on the Red Sea. In 1885 the troubles in which Egypt found herself involved compelled the Khedive and his advisers to loosen their hold on the Red Sea littoral, and, with the tacit approval of Great Britain, Italy took possession of Massawa and other ports on that coast. By 1888 Italian influence had been extended from Ras Kasar, on the north, to the northern frontier of the French colony of Obok on the south, a distance of some 650 miles. The interior limits of Italian influence were but ill defined, and King John of Abyssinia viewed with anything but a favourable eye the approach of the Italians towards the Abyssinian highlands. In January 1887 an Italian force was almost annihilated at Dogali, but the check only served to spur on the Italian Government to fresh efforts. The Italians occupied Keren and Asmara in the interior, and eventually, in May 1889, concluded a treaty of peace and friendship with the Emperor Menelek, who had succeeded King John on the death of the latter in battle with the dervishes. This agreement, known as the Treaty of Ucialli, settled the frontiers between Abyssinia and the Italian sphere, and contained the following article:—

> XVII. His Majesty the King of Kings of Ethiopia consents to avail himself of the Italian Government for any negotiations which he may enter into with the other Powers or Governments.

In Italy, and by other European Governments, this article was generally regarded as establishing an Italian protectorate over Abyssinia; but this interpretation was never accepted by the Emperor Menelek, and at no time did Italy succeed in establishing any very effective control over Abyssinian affairs. North of the Italian coast sphere the Red Sea littoral was still under Egyptian rule, while immediately to the south a small stretch of coast on the Bay of Tajura constituted the sole French possession on the East African mainland. France had, in 1862, obtained from the Danakil tribes a concession of "the harbour, roadstead, and anchorage of Obok, situated near Cape Ras Bir, with the plain extending from Ras Aly to the south, as far as Ras Dumeirah to the north." It was not, however, until 1883 that the place was effectively occupied, and in the following year treaties were concluded with the Sultan and chiefs of Tajura extending the French sphere to the southern side of the gulf of that name. The East India Company had, as far back as 1840, concluded a treaty of friendship with the governor or chief of Zeila, not far from the Bay of Tajura; and when Egyptian claims to the Somali coast were withdrawn Great Britain took the opportunity to establish her influence on the northern Somali coast, opposite Aden. Between 1st May 1884 and 15th March 1886 ten treaties were concluded, placing under British influence the northern Somali coast from Ras Jibuti on the west to Bunder Ziadeh on the east. In the meantime Italy, not content with her acquisitions on the Red Sea, had been concluding treaties with the Somali chiefs on the east coast. The first treaty was made with the Sultan of Oppia on the 8th February 1889. Later in the same year the British East Africa Company transferred to Italy, the transference being subsequently approved by the Sultan of Zanzibar, the ports of Brava, Meurka, Magadisho, and Warshekh, leased from Zanzibar. On the 24th March 1891 an agreement between Italy and Great Britain fixed the northern bank of the Juba up to latitude 6° N. as the southern boundary of Italian influence in Somaliland, the boundary being provisionally prolonged along lines of latitude and longitude to the intersection of the Blue Nile with 35° E. longitude. On the 15th April 1891 a further agreement fixed the northern limit of the Italian sphere from Ras Kasar on the Red Sea to the point on the Blue Nile just mentioned. By this agreement Italy was to have the right of temporarily occupying Kassala, which was left in the Anglo-Egyptian sphere—in trust for Egypt—a right of which she availed herself in 1895. To complete the work of delimitation the British and Italian Governments, on the 5th May 1894, fixed the boundary of the British sphere of influence in Somaliland from the Anglo-French boundary, which had been settled in February 1888. The interior limit of British Somaliland thus agreed upon was subsequently modified in 1897 by an agreement with the Emperor Menelek, made by Sir Rennell Rodd on behalf of Great Britain. The effect of this agreement was to reduce the area of British Somaliland from 75,000 to 68,000 square miles.

But while Great Britain was thus lending her sanction to Italy's ambitious schemes, the Abyssinian emperor was becoming more and more incensed at Italy's pretensions to exercise a protectorate over Ethiopia. In 1883 Menelek denounced the treaty of Uciali, and eventually, in a great battle, fought at Adowa on 1st March 1896, the Italians were disastrously defeated. By the subsequent treaty of Addis Abbaba, concluded on 26th October 1896, the whole of the country to the south of the Mareb, the Belesa, and Muna rivers was restored to Abyssinia, and Italy acknowledged the absolute independence of Abyssinia. The effect of this was practically to destroy the value of the Anglo-Italian agreement as to the boundaries to the south and west of Abyssinia; and negotiations were afterwards set on foot between the British, the Egyptian, and the Abyssinian Governments for determining the Abyssinian frontiers.

Egypt; Morocco.

The position of Egypt is theoretically unchanged since the abolition of the Dual Control, though in fact British influence is now recognized as virtually paramount in Egypt proper. In the reconquered Anglo-Egyptian Sudan, which consists of the territory south of the 22nd parallel of latitude, the administration is carried on in accordance with the terms of a convention between the British and Egyptian Governments, signed at Cairo, 19th January 1899, under which the British and Egyptian flags are used together. Tripoli still remains a Turkish province. In Tunis the French protectorate has practically eliminated the Bey for all but ceremonial purposes. In Algeria France, in her progress south and south-west, has come into conflict with Morocco. In the closing days of 1899 an attack by some of the inhabitants of the Tidikelt oasis on a French "scientific" mission furnished the occasion for which France had long been seeking for the occupation of a number of groups of oases in the western Sahara, known as the Tuat Oases, and consisting of Tuat, Tidikelt, and Gurara. The last two groups were occupied by French troops after some fighting, and at the end of 1900 France was preparing to make good her hold on these two groups and to establish her influence in Tuat proper, the Sultan of Morocco having protested to the European Powers against the action of France and asked for their intervention. The occupation of Igli, half-way between the frontier of Morocco proper and Tuat, by French troops further excited the Sultan's subjects. The claim of Morocco was that the tribes of the oases owed allegiance to the Sultan, and that France acknowledged them to be within the Moorish sphere of influence by the treaty of 1845, which is the only document fixing the frontier between Morocco and Algeria. At the opening of the Berlin Conference Spain had established no formal claim to any part of the coast to the south of Morocco; but while the conference was sitting, on 9th January 1885, the Spanish Government intimated that in view of the importance of the Spanish settlements on the Rio Oro, at Angra de Cintra, and at Western Bay, and of the documents signed with the independent tribes on that coast, the King of Spain had taken under his protection "the territories of the western coast of Africa comprised between the fore-mentioned Western Bay and Cape Bajador." Numerous attempts were made with France to settle the landward extension of Spain's possessions in this part of Africa, both Governments claiming to include the Adrar country within their sphere of influence; but in 1900 an agreement was come to by which Spain recognized the French claim to Adrar and agreed to the twelfth meridian west of Greenwich being the eastern boundary of the Spanish sphere, north of the Tropic of Cancer, the boundary line to the south being deflected westwards so as to leave the Sebkha, or dry salt lake, of Ijil to France. The same agreement settled a long-standing dispute between Spain and France as to the ownership of the district around the Muni river to the south of Cameroon, and Spain secured a block of territory, with a coast-line from the Campo river on the north to the Muni river on the south. The northern frontier is formed by the German Cameroon colony, the eastern by 11° 20′ E., and the southern by the 1st parallel of north latitude to its point of intersection with the Muni river.

Division of West Africa.

Apart from this small block of Spanish territory south of Cameroon, the stretch of coast between Cape Blanco and the mouth of the Congo is partitioned among four European Powers—Great Britain, France, Germany, and Portugal—and the negro republic of Liberia. Following the coast southwards from Cape Blanco we come first to the French colony of Senegal, which is indented, along the Gambia river, by the small British colony of that name, and then to the comparatively small territory of Portuguese Guinea, all that remains on this coast to represent Portugal's share in the scramble in a region where she once played so conspicuous a part. To the south of Portuguese Guinea is the French Guinea colony, and still pursuing our way south and east we come to the British colony of Sierra Leone, the republic of Liberia, the French colony of the Ivory Coast, the British Gold Coast, German Togoland, French Dahomey, the British colony of Lagos, the British territory of Southern Nigeria, the German colony of Cameroon, the Spanish settlements on the Muni river, the French Gabun colony, and the small Portuguese *enclave* north of the Congo, of which the principal town is Kabinda, which is administratively part of the Angola colony. When the General Act of the Berlin Conference was signed the whole of this coast-line had not been formally claimed; but no time was lost by the Powers interested in notifying claims to the unappropriated sections, and the conflicting claims put forward necessitated frequent adjustments by international agreements. Before describing the results of these agreements, both on the coast and in the interior, it may be interesting to glance briefly at one or two of the main features of the problem which so many rival Powers were approaching from their several standpoints. The dominant part in West Africa has been played by France. Her anxiety to connect her West African possessions with Southern Algeria, and her Congo colony with both, has already been alluded to. Ancillary to this desire was the wish to establish a continuous territorial connexion between her scattered possessions on the West African coast. When this design was consciously adopted as the object of French statesmanship, it is very difficult to say; but for several years before the Berlin Conference military and exploring expeditions had been pushed forward into the great Niger bend from the upper waters of the Senegal, and the purpose became clearer and more defined in the strenuous years of struggle that followed the Conference. The exhaustion of Portugal, the apathy of the British Government, and the late arrival of Germany in the field, are all elements that favoured the success of France's West African policy. If, in her larger design of joining on her empire in the Western Sudan to her possessions on the Congo, she experienced a check by reason of the vigour with which British interests were pushed on the Middle Niger and eastwards to Lake Chad, the credit for this cannot be claimed by the British Government, but is due entirely to the Royal Niger Company and its distinguished governor, Sir George Taubman Goldie. France's double object was to secure as large a share of the Niger basin as possible, and to make Lake Chad a French lake. In this latter object she was not wholly successful, and for the much-desired communication between the Western Sudan and the Congo was reluctantly compelled to go round the northern and eastern shores of the lake, instead of through the richer and more populous regions to the west and south of the lake. The real struggle in West Africa was between France and Great Britain; but before tracing the steps of that historic contest, it may be well to deal briefly with the part played by the other Powers in West Africa.

Portuguese Guinea.

Portuguese Guinea, with a coast-line of some 200 miles, is entirely surrounded by French possessions. Its frontiers were fixed by an agreement signed at Paris on the 12th May 1886. The northern frontier extends almost due east from Cape Roxo for about 200 miles, then the boundary turns due south for 80 or 90 miles, and then sweeps west and south in a curve to the mouth of the river Cajet. By another article in the same agreement the boundaries of the Portuguese Congo *enclave* with the French Congo colony are determined.

Liberia.

The negro republic of Liberia has a coast-line of about 350 miles in length, stretching from the river Mano and the frontier of Sierra Leone to the river Cavally and the French Ivory Coast. Its interior limits were fixed by agreements with Great Britain on the 11th November 1885, and with France on the 8th December 1892. Starting from the left bank of the Mano river, the frontier extends generally in a north-easterly and northern direction, the coast-line having been traced by an Anglo-Liberian Boundary Commission, until it reaches a point about half-way between the 8th and 9th parallels of north latitude, when it strikes due east to beyond the 9th meridian of west longitude, then strikes south-east, and after a short run due east intersects the Cavally river, which it follows to the coast.

Germany and Cameroon.

It will be remembered that Dr Nachtigal, while the proposals for the Berlin Conference were under discussion, had planted the German flag on the coast of Togo and in Cameroon in the month of July 1884. In Cameroon Germany found herself with Great Britain for a neighbour to the north, and with France as her southern neighbour on the Gabun river. The utmost activity was displayed in making treaties with native chiefs, and in securing as wide a range of coast for German enterprise as was possible. In May 1885 a provisional agreement was made between Great Britain and Germany as to the northern limits of Germany's activity. This was subsequently modified in August 1886, and on the 28th March 1887 Great Britain renounced in favour of Germany her sovereignty over Ambas Bay. In the famous agreement of 1st July 1890 a "provisional line of demarcation" was adopted, starting from the head of the Rio del Rey creek and going to the point, about 9° 8′ E. longitude, marked "rapids" on the British Admiralty Chart. By a further agreement of 14th April 1893, the right bank of the Rio del Rey was made the boundary between the Oil Rivers Protectorate (now Southern Nigeria) and Cameroon. In the following November (1893) the boundary was continued from the "rapids" before mentioned, on the Old Calabar or Cross river, in a straight line towards the centre of the town of Yola, on the Benué river. Yola itself, with a radius of some 3 miles, was left in the British sphere, and the German boundary followed the circle eastwards from the point of intersection as it neared Yola until it met the Benué river. From that point it crossed the river to the intersection of the 13th degree of longitude with the 10th degree of north latitude, and then made direct for a point on the southern shore of Lake Chad "situated 35 minutes east of the meridian of Kuka, this being the distance between the meridian of Kuka and the 14th meridian east of Greenwich, measured on the map (by Kiepert) published in the German *Kolonial Atlas* of 1892." Provision was made for settling a new terminal point of the German boundary on Lake Chad, should our present want of knowledge of the geography of that region render such an alteration desirable. By this agreement the British Government withdrew from a considerable section of the upper waters of the Benué with which the Royal Niger Company had entered into relations. The object of making this sacrifice was, however, apparent. France was, as we have seen, eagerly desirous of securing the whole of Lake Chad for herself. By giving Germany access to the lake Great Britain at the same time satisfied German ambition as to the hinterland of the Cameroon colony and interposed a barrier against the junction of the French Congo and the French Sudan to the south and west of the lake. The limit of Germany's possible extension eastwards was fixed at the basin of the river Shari, and Darfur, Kordofan, and the Bahr-el-Ghazal were to be excluded from her sphere of influence. Germany now found herself in a position to come to terms with France as to the southern and eastern limits of Cameroon. She had already, on the 24th December 1885, signed a protocol with France fixing her southern frontier from the mouth of the river Campo to the intersection of that river with the 10th degree of east longitude, thence along the parallel of latitude to the point of its intersection with 15° E. longitude. But to the east German explorers were crossing the track of French explorers from the northern bank of the Mobangi, and the need for an agreement was obvious. Accordingly, on the 4th February 1894, a protocol—which, some weeks later, was confirmed by a convention—was signed at Berlin, by which France accepted the presence of Germany on Lake Chad as a *fait accompli* and effected the best bargain she could by making the left bank of the Shari river, from its outlet into Lake Chad to the 10th parallel of north latitude, the eastern limit of German extension. From this point the boundary line went due west some 230 miles, then turned south, and with various indentations joined the south-eastern frontier, which had been slightly extended so as to give Germany access to the Sangha river—a tributary of the Congo. Thus, early in 1894, the German Cameroon colony had reached its present definite limits.

Togoland.

The German Togoland Settlements occupy a narrow strip of the Guinea Coast, some 35 miles only in length, wedged in between the British Gold Coast and French Dahomey. At first France was inclined to dispute Germany's claims to Little Popo and Porto Seguro; but in December 1885 the French Government acknowledged the German protectorate over these places, and the boundary between French and German territory, which runs in an irregular line almost due north from the coast to the 11th degree of latitude, was laid down by the Franco-German Convention of 12th July 1897. It was not, however, until the end of 1899, after two years of arduous and constantly-interrupted labours, that the Joint Commission completed the work of delimitation. The fixing of the 11th parallel as the northern boundary of German expansion towards the interior was not accomplished without some sacrifice of German ambitions. Having secured an opening on Lake Chad for her Cameroon colony, Germany was anxious to obtain a footing on the Middle Niger for Togoland. German expeditions reached Gando, one of the tributary states of the Sokoto empire on the Middle Niger, and, notwithstanding the existence of prior treaties with Great Britain, sought to conclude agreements with the Sultan of that country. But this German ambition conflicted both with the British and the French designs in West Africa, and eventually Germany had to be content with the 11th parallel as her northern frontier. On the west the Togoland frontier on the coast was fixed in July 1886 by British and German commissioners at 1° 10′ E. longitude, and its extension towards the interior laid down for a short distance. By a further agreement in 1888 the boundary was extended so as to leave the district of Towe, Kowe, and Agotime within the German sphere, and to include the countries of Aquamoo and Crepee within the British protectorate. A neutral zone farther north was also agreed upon at the same time. The agreement of 1st July 1890, already so frequently referred to, defined the limits up to this neutral zone; but it was not until November 1899 that, as part of the Samoa Settlement, this neutral zone was partitioned between the two Powers in such a manner as to leave the important trading centre of Salaga to Great Britain and that of Yendi to Germany. At the same time the territory to the north of the neutral zone up to the 11th parallel was divided between the Gold Coast and Togoland, and the present limits of both colonies were then definitely determined.

Anglo-French competition in West Africa.

The story of the struggle between France and Great Britain in West Africa may roughly be divided into two sections, the first dealing with the Coast colonies, the second dealing with the struggle for the Middle Niger and Lake Chad. As regards the coast colonies, France was wholly successful in her design of isolating all Great Britain's separate possessions in that region, and of securing for herself undisputed possession of the Upper Niger and of the countries lying within the great bend of that river. When too late, the British Government awoke to the consciousness of what was at stake; but France had obtained too great a start. French governors of the Senegal had succeeded, before the Berlin Conference, in establishing forts on the Upper Niger, and the advantage thus gained was steadily pursued. Every winter season French posts were pushed farther and farther along the river, or in the vast regions watered by the southern tributaries of the Senegal and Niger rivers. The two most formidable chiefs encountered by France were Ahmadu, a son of the famous El-Haj-Omar, and Samory, a man of humble origin who had risen by force of character to be the ruler of an immense area of country in the Upper Niger basin. Campaign after campaign was fought against this formidable chief by Gallieni, Desbordes, Frey, Archinard, and other French officers; but it was not until September 1898 that Samory's power was finally broken, and he himself captured. In 1887 the Almamy of Futa Jallon, who had formerly been anxious to obtain British protection, signed a treaty placing the whole of that mountainous region under French protection. Simultaneously with her military operations France undertook a series of splendid exploring expeditions in the Niger countries. In 1888-90 Captain Binger traversed the regions between the Upper Niger and the Guinea Coast, making treaties all along his route. In the campaign of 1890-91 Sego, one of Ahmadu's principal towns, was captured by Colonel Archinard. In 1891-92 Captain Monteil traversed the Niger bend from west to east, and from Say made his way to Lake Chad, returning to Europe across the Sahara to the Mediterranean. In December 1893 Timbuktu was occupied by Colonel Bonnier, in defiance of the order of the civil authorities, and every year saw one or more fresh expeditions launched by France, regardless of cost, into the Niger basin. This ceaseless activity met with its reward. Great Britain found herself compelled to acknowledge accomplished facts and to conclude agreements with France, which left her colonies mere coast patches, with a very limited extension towards the interior. On the 10th August 1889 an agreement was signed by which the Gambia colony and protectorate was confined to a narrow strip of territory on both banks of the river for about 200 miles from the sea. In June 1882 and in August 1889 provisional agreements were made with France fixing the western and northern limits of Sierra Leone, and commissioners were appointed to trace the line of demarcation agreed upon by the two Governments. But the commissioners failed to agree, and on the 21st January 1895 a fresh agreement was made, the boundary being subsequently traced by a mixed commission. Sierra Leone, as now definitely constituted, has a coast-line of about 180 miles and a maximum extension towards the interior of some 200 miles.

At the date of the Berlin Conference the present colonies of Lagos and the Gold Coast constituted a single colony under the title of the Gold Coast Colony, but on the 13th January 1886 the Gold Coast Settlements were erected into a separate colony. The coast limits of the new colony were declared to extend from 5° W. longitude to 2° E. longitude, but these limits were subsequently curtailed by agreements with France and Germany. We have already followed the course of the arrangements that fixed the eastern frontier of the Gold Coast Colony and its hinterland in connexion with German Togoland. On the western frontier it marches with the French colony of the Ivory Coast, and in August 1889 the two Governments agreed that the frontier should start from the neighbourhood of the Tanoe lagoon, and river of the same name, and should be prolonged to the 9th degree of north latitude in accordance with the treaties concluded by the two Governments with the natives, Great Britain being allowed full liberty of action as regards the Ashantis. Commissioners having failed to agree as to the delimitation of the frontier, plenipotentiaries were appointed in Europe by the two Governments, and on the 12th July 1893 an agreement was signed setting out in detail the course of the frontier up to the 9th degree of north latitude. In August 1896, following the destruction of the Ashanti power and the deportation of King Prempeh, as a result of the second Ashanti campaign, a British protectorate was declared over the whole of the Ashanti territories and a Resident was installed at Kumassi. But no northern limit had been fixed by the 1893 agreement beyond the 9th parallel, and the countries to the north—Gurunsi (Grusi), Mossi, and Gurma—were entered from all sides by rival British, French, and German expeditions. The conflicting claims established by these rival expeditions may, however, best be considered in connexion with the struggle for supremacy on the Middle Niger, and in the Chad region, to which we must now turn.

The Middle Niger and Lake Chad.

A few days before the meeting of the Berlin Conference Sir George Goldie had succeeded in buying up all the French interests on the Lower Niger. The British company's influence had at that date been extended by treaties with the native chiefs up the main Niger stream to its junction with the Benué, and some distance along this latter river. But the great Fulah States of the Central Sudan were still outside European influence, and this fact did not escape attention in Germany. German merchants had been settled for some years on the coast, and one of them, Herr Flegel, had displayed great interest in, and activity on, the river. He recognized that in the densely-populated States of the Middle Niger, Sokoto and Gando, and in Bornu to the west of Lake Chad, there was a magnificent field for Germany's new-born colonizing zeal. The German African Society and the German Colonial Society listened eagerly to Herr Flegel's proposals, and in April 1885 he left Berlin on a mission to the Fulah states of Sokoto and Gando. But it was impossible to keep his intentions entirely secret, and the British National African Association had no desire to see the French rivals, whom they had with so much difficulty dislodged from the river, replaced by the even more troublesome German. Accordingly Mr Joseph Thomson, the young Scottish explorer, was sent out to the Niger, and had the satisfaction of concluding on the 1st June 1885 a treaty with "Umoru, King of the Mussulmans of the Sudan and Sultan of Sokoto," which practically secured the whole of the trading rights and the control of the Sultan's foreign relations to the British company. Mr Thomson concluded a similar treaty with the Sultan of Gando, so as to provide against the possibility of its being alleged that Gando was an independent state and not subject to the suzerainty of the Sultan of Sokoto. As Mr Thomson descended the river with his treaties, he met Herr Flegel going up the river, with bundles of German flags and presents for the chiefs. The German Government recognized that they had been forestalled, and, except for the despairing attempt many years later to establish relations with Gando from Togoland, Germany dropped out of the competition for the Western Sudan and left the field to France and Great Britain. After this first great success the National African Company renewed its efforts to obtain a charter from the British Government, and on the 10th July 1886 the charter was granted, and the company became "The Royal Niger Company, chartered and limited." In June of the previous year a British protectorate had been proclaimed over the whole of the coast from the Rio del Rey to the Lagos frontier, and on the 13th January 1886 the Lagos Settlements had been separated from the Gold Coast and erected into a separate colony. It may be convenient to state here that the eastern boundary of Lagos with French territory was determined in the Anglo-French agreement of 10th August 1889, which provided that "the line of demarcation between the spheres of influence of the two powers shall be identical with the meridian which intersects the territory of Porto Novo at the Ajarra creek, leaving Pokrah, or Pokéa, to the English colony of Lagos. It shall follow the above-mentioned meridian as far as the 9th degree of north latitude, where it shall stop." Thus both in the Gold Coast hinterland and in the Lagos hinterland a door was left wide open to the north of the 9th parallel.

Notwithstanding her strenuous efforts, France, in her advance down the Niger from Senegal, did not succeed in reaching Sego until the winter of 1890-91, and the rapid advance of British influence up the river raised serious fears lest the Royal Niger Company should reach Timbuktu before France could forestall her. It was, no doubt, this consideration that induced the French Government to consent to the insertion in the agreement of 5th August 1890, by which Great Britain recognized France's protectorate over Madagascar, of the following article:—

> The Government of Her Britannic Majesty recognizes the sphere of influence of France to the south of her Mediterranean possessions up to a line from Say on the Niger to Barruwa on Lake Chad, drawn in such a manner as to comprise in the sphere of action of the Niger Company all that fairly belongs to the kingdom of Sokoto; the line to be determined by the commissioners to be appointed.

The commissioners never were in fact appointed, and the proper meaning to be attached to this article subsequently became a subject of bitter controversy between the two countries. An examination of the map of West Africa will show what possibilities of trouble were left open at the end of 1890 by the various agreements concluded up to that date. From Say on the Niger to the northern limit of the Lagos frontier there was no boundary line between the French and British spheres of influence. To the north of the Gold Coast and of the French Ivory Coast Colony the way was equally open to Great Britain and to France, while the vagueness of the Say-Barruwa line left an opening of which France was quick to avail herself. Captain Monteil started on his journey in 1890, immediately after the conclusion of the August agreement; but he did not hesitate to pass well to the south of the Say-Barruwa line, and to attempt to conclude treaties with chiefs who were, beyond all question, within the British sphere. Still farther south, on the Benué river, the two expeditions of Lieutenant Mizon—in 1890 and in 1892—failed to do any real harm to British interests.

In 1892 an event happened which had an important bearing on the future course of the dispute. After a troublesome war with Behanzin, king of the important native state of Dahomey, France annexed some portion of Dahomeyan territory on the coast, and declared a protectorate over the rest of the kingdom. In 1894 Dahomey was divided into two kingdoms, and the new sovereigns were appointed by France and accepted the French protectorate. Thus was removed the barrier which had up to that time prevented France from pushing her way Nigerwards from her possessions on the Slave Coast, as well as from the Upper Niger and the Ivory Coast. Meanwhile her progress from both these directions had been considerable, and in particular Timbuktu had been occupied in the last days of 1893.

In 1894 it appears to have been suddenly realized in France that, for the development of the vast regions which she was placing under her protection in West Africa, it was extremely desirable that she should obtain free access to the navigable portions of the Niger. In the neighbourhood of Bussa there is a long stretch of the river so impeded by rapids that navigation is practically impossible, except in small boats and at considerable risk. Below these rapids France had no foothold on the river, both banks from Bussa to the sea being within the British sphere. In 1890 the Royal Niger Company had concluded a treaty with the Emir and chiefs of Bussa (or Borgu); but the French declared that the real paramount chief of Borgu was not the king of Bussa, but the king of Nikki, and three expeditions were despatched in hot haste to Nikki to take the king under French protection. Sir George Goldie, however, was not to be baffled. While maintaining the validity of the earlier treaty with Bussa, he despatched Captain (now General) Lugard to Nikki, and Captain Lugard was successful in distancing all his French competitors by several days, reaching Nikki on the 5th November 1894, and concluding a treaty with the king and chiefs. The French expeditions, which were in great strength, did not hesitate on their arrival to compel the king to execute fresh treaties with France, and with these in their possession they returned to Dahomey. Shortly afterwards a fresh act of aggression was committed. On 13th February 1895 a French officer, Commandant Toutée, arrived on the right bank of the Niger opposite Bajibo and built a fort. His presence there was notified to the Royal Niger Company, who protested to the British Government against this invasion of their territory. Lord Rosebery, who was then foreign minister, at once made inquiries in Paris, and received the assurance that Commandant Toutée was "a private traveller." Eventually Commandant Toutée was ordered to withdraw, and the fort was occupied by the Royal Niger Company's troops. Commandant Toutée subsequently published the official instructions from the French Government under which he had acted. It was thought that the recognition of the British claims, involved in the withdrawal of Commandant Toutée, had marked the final abandonment by France of the attempt to establish herself on the navigable portions of the Niger below Bussa, but in 1897 the attempt was renewed in the most determined manner. In February of that year a French force suddenly occupied Bussa, and this act was quickly followed by the occupation of Gomba and Ilo higher up the river. In November 1897 Nikki was occupied. The situation on the Niger had so obviously been outgrowing the capacity of a chartered company that for some time before these occurrences the assumption of responsibility for the whole of the Niger region by the Imperial authorities had been practically decided on; and early in 1898 Colonel Lugard was sent out to the Niger with a number of Imperial officers to raise a local force in preparation for the contemplated change. The advance of the French forces from the south and west was the signal for an advance of British troops from the Niger, from Lagos, and from the Gold Coast protectorate. The situation thus created was extremely serious. The British and French flags were flying in close proximity, in some cases in the same village. Meanwhile the diplomatists were busy in London and in Paris, and in the latter capital a commission sat for many months to adjust the conflicting claims. Fortunately, by the tact and forbearance of the officers on both sides, no local incident occurred to precipitate a collision, and on the 14th June 1898 a convention was signed by Sir Edward Monson and M. Hanotaux, which finally removed all causes of dispute as to the spheres of influence of the two countries in West Africa; and, subject to the division of the small area in the hinterland of the Gold Coast and Togoland between Great Britain and Germany, which was effected in November 1899, completed the partition of this part of the continent.

The Anglo-French agreement of June 1898.

The settlement effected was in the nature of a compromise. France withdrew from Bussa, Gomba, and Ilo, the frontier line west of the Niger being drawn from the 9th parallel to a point 10 miles, as the crow flies, above Giri, the port of Ilo. France was thus shut out from the navigable portion of the Middle and Lower Niger; but for purely commercial purposes Great Britain agreed to lease to France two small plots of land on the river—the one on the right bank between Leaba and the mouth of the Moshi river, the other at one of the mouths of the Niger. By accepting this line Great Britain abandoned Nikki and a great part of Borgu, as well as some part of Gando to France. East of the Niger the Say-Barruwa line was modified in favour of France. From the point indicated 10 miles above Giri the boundary follows the Niger as far as the mouth of a dry water-course called the Dallul Mauri, which it follows till it cuts the circumference of a circle drawn from the centre of the town of Sokoto with a radius of a hundred miles. The line then follows the northern arc of this circle till its point of intersection with the 14th parallel of north latitude, which it follows eastwards for a distance of 70 miles, then dips due south until it reaches the parallel of 13° 20′ north latitude, then runs eastwards along this parallel for a distance of 250 miles, then turns due north until it regains the 14th parallel, then runs eastwards again along that parallel as far as its intersection with the meridian, passing 35′ east of the centre of the town of Kuka, and thence follows this meridian southwards until its intersection with the southern shore of Lake Chad, at which point, it will be remembered, the Anglo-German frontier reaches its northern limit. This line assigns to France parts of both Sokoto and Bornu. In the Gold Coast hinterland the French withdrew from Wa, and Great Britain abandoned all claim to Mossi, though the capital of the latter country, together with a further extensive area in the territory assigned to both countries, is declared to be equally free, so far as trade and navigation are concerned to the subjects and protected persons of both nationalities. The western boundary of the Gold Coast was prolonged along the Black Volta as far as latitude 11° north, and this parallel was followed with slight deflections to the Togoland frontier. In consequence of the acute crisis which shortly afterwards occurred between France and Great Britain on the Upper Nile, the ratification of this agreement was delayed until after the conclusion of the Fashoda agreement of March 1899 already referred to. In 1900 the two patches on the Niger leased to France were selected by commissioners representing the two countries, and in the same year the Anglo-French frontier from Lagos to the west bank of the Niger was delimited. But east of the Niger to Lake Chad it had not been found possible even to make a survey of the country through which the boundary will run, before the close of the 19th century.

The settlement of the matters in dispute with France enabled the British Government to carry out several changes in the administration of British Nigeria, which had been in contemplation for some time. On the 1st January 1900 the Imperial authorities took over the whole of the territories of the Royal Niger Company, which, with reduced capital, became henceforth a purely commercial undertaking. The Lagos protectorate was extended to the northwards, the Niger Coast Protectorate became Southern Nigeria with extended frontiers, and the greater part of the territories formerly administered by the company were constituted into Northern Nigeria—all three administrations being placed under the Colonial Office. In like manner France, having definitely fixed her international frontiers, turned her attention to a rearrangement of her possessions. The French Sudan was abolished as an administrative entity, large slices of territory were added on to Dahomey, the Ivory Coast Colony, French Guinea, and Senegal, the portions not assigned to these colonies, all of which were placed under civil administration, being created military districts. For the limits assigned to the various French colonies in West Africa, reference must be made to the articles dealing with each.

African islands.

There are, around the coast, numerous islands or groups of islands, which are regarded by geographers as outliers of the African mainland. The majority of these African islands were occupied by one or other of the European Powers long before the period of continental partition. The Madeira Islands to the west of Morocco; the Bissagos Islands, off the Guinea Coast; and Prince's Island and St Thomas' Island, in the Gulf of Guinea, are Portuguese possessions of old standing; while in the Canary Islands and Fernando Po Spain possesses remnants of her ancient colonial empire which are a more valuable asset than any she has acquired in recent times on the mainland. St Helena in the Atlantic, Mauritius, and some small groups north of Madagascar in the Indian Ocean, are British possessions acquired long prior to the opening of the last quarter of the 19th century. Zanzibar, Pemba, and some smaller islands which the Sultan was allowed to retain were, as has already been stated, placed under British protection in 1890, and the island of Socotra was placed under the "gracious favour and protection" of Great Britain on 23rd April 1886. France's ownership of Réunion dates back to the 17th century, but the Comoro Archipelago was not placed under French protection until April 1886. None of these islands, with the exception of the Zanzibar group, have, however, materially affected the partition of the continent and they need not be enumerated in the table which follows. But the important island of Madagascar stands in a different category, both on account of its size and because it was during the period under review that it passed through the various stages which led up to its becoming a French colony. The first step was the placing of the foreign relations of the island under French control, which was effected by the treaty of 17th December 1885, following the Franco-Malagasy war that had broken out in 1883. In 1890 Great Britain and Germany recognized a French protectorate over the island, but the Hova government declined to acquiesce in this view, and in May 1895 France sent an expedition to enforce her claims. The capital was occupied on 1st October in the same year, when Queen Ranava'ona signed a convention recognizing the French protectorate. In January 1896 the island was declared a French possession, and on 6th August was declared to be a French colony. In February 1897 the last vestige of ancient rule was swept away by the deportation of the queen.

The Brussels Act of 1890.

Although the "Brussels Act" of 1890 did not affect the actual territorial partition of Africa, it had a direct bearing on the manner in which the Powers discharged the obligations which they assumed in acquiring African territory, and must therefore be briefly referred to here. The British Government had for long borne the greater part of the burden of combating the slave trade on the east coast of Africa and in the Indian Ocean, but the changed conditions which resulted from the appearance of other European Powers in Africa induced Lord Salisbury, then foreign secretary, to address, in the autumn of 1888, an invitation to the King of the Belgians to take the initiative in inviting a conference of the Powers at Brussels to concert measures for "the gradual suppression of the slave trade on the continent of Africa, and the immediate closing of all the external markets which it still supplies." The conference assembled in November 1889, and on the 2nd July 1890 a "General Act" was signed subject to the ratification of the various Governments represented, ratification taking place subsequently at different dates, and in the case of France with certain reservations. The General Act began with a declaration of the means which the Powers were of opinion might be most effectually adopted for "putting an end to the crimes and devastations engendered by the traffic in African slaves, protecting effectively the aboriginal populations of Africa, and ensuring for that vast continent the benefits of peace and civilization." It proceeded to lay down certain rules and regulations of a practical character on the lines suggested. The Act covers a wide field, and includes no less than a hundred separate articles. It established a zone "between the 20th parallel of north latitude and the 22nd parallel of south latitude, and extending westward to the Atlantic Ocean and eastward to the Indian Ocean and its dependencies, comprising the islands adjacent to the coast as far as 100 nautical miles from the shore," within which the importation of firearms and ammunition was forbidden except in certain specified cases, and within which also the Powers undertook either to prohibit altogether the importation and manufacture of spirituous liquors, or to impose duties not below an agreed-on minimum. An elaborate series of rules were framed for the prevention of the transit of slaves by sea, the conditions on which European Powers were to grant to natives the right to fly the flag of the protecting Power, and regulating the procedure connected with the right of search on vessels flying a foreign flag. The Brussels Act was in effect a joint declaration by the signatory Powers of their joint and several responsibility towards the African native, and notwithstanding the fact that many of its articles have proved difficult, if not impossible, of enforcement, the solemn engagement taken by Europe in the face of the world has undoubtedly exercised a material influence on the action of several of the Powers.

The position in 1900.

Thus by the close of the 19th century the political partition of Africa had practically been completed. There remained still for settlement various questions of frontier, as between Great Britain, Egypt, and Abyssinia in North-East Africa, and between France and Morocco in the north-western corner of the continent. The limits of Barotseland to the west had to be determined by Great Britain and Portugal, and much delimitation work had still to be done. But in its broad outlines the partition of Africa was begun and ended in the short space of a quarter of a century. Much labour is necessary before the actual area of the continent and its subdivisions can be accurately determined, but in the following table the figures are at least approximately correct, and may be taken to represent the political situation in Africa, from the European standpoint, at the opening of the 20th century. It is perhaps well to add that in fact large areas of the spheres assigned to different European Powers are still under native rulers who have in no way admitted the title of their European overlords.

POSITION IN 1900.

	Square Miles.
BRITISH—	
Cape Colony	277,151
Natal and Zululand	29,434
Basutoland	10,293
Bechuanaland	386,200
Transvaal Colony	119,139
Orange River Colony	48,326
Rhodesia	600,000
British Central Africa Protectorate	42,217
British East Africa and Uganda Protectorates (including Nile basin to 10° N.)	670,000
Somaliland	68,000
Northern Nigeria	310,000
Southern Nigeria	21,500
Lagos and Yoruba	20,500
Gold Coast (and *hinterland*)	74,500
Sierra Leone	33,100
Gambia	3,550
Total British Africa	2,713,910
FRENCH—	
Algeria Proper	184,474
Algerian Sahara	123,500
Tunis	51,000
Senegal	182,000
Guinea	92,000
Ivory Coast	119,500
Dahomey	59,000
Sudan Military Districts	183,000
Congo and Gabun	550,000
Bagirmi, Wadai, Kanem	126,000
Sahara, including Tibesti	1,892,000
Somaliland	14,000
Madagascar	228,500
Total French Africa	3,804,974
GERMAN—	
East Africa	385,000
South-West Africa	322,450
Cameroon	191,130
Togoland	34,800
Total German Africa	933,380
ITALIAN—	
Eritrea	88,500
Somaliland	100,000
Total Italian Africa	188,500
PORTUGUESE—	
Guinea	4,394
Angola	484,730
East Africa	301,000
Total Portuguese Africa	790,124

SPANISH—	
Rio de Oro	167,400
Muni River	1,750
Total Spanish Africa	169,150
TURKISH—	
Tripoli and Benghazi	398,900
EGYPTIAN—	
Egypt Proper	400,000
Anglo-Egyptian Sudan	610,000
Total Egyptian Africa	1,010,000
SEPARATE STATES—	
Congo Free State	900,000
Liberia	52,000
Morocco	219,000
Abyssinia	320,000
Total Independent Africa	1,491,000

Thus, collecting the totals, we see that at the present day (1901) Africa is portioned out among the Powers as follows:—

	Square Miles.
British Africa	2,713,910
French Africa (including Madagascar)	3,804,974
German Africa	933,380
Italian Africa	188,500
Carried forward	7,640,765
Brought forward	7,640,764
Portuguese Africa	790,124
Spanish Africa	169,150
Turkish Africa	398,900
Egyptian Africa	1,010,000
Independent Africa	1,491,000
Total Africa (including Madagascar)	11,499,938

AUTHORITIES.—HERTSLET. *Map of Africa by Treaty*, 3 vols. London, 1896.—SCOTT KELTIE. *Partition of Africa*, 2nd ed. London, 1895.—SILVA WHITE. *Development of Africa*. London, 1892.—BANNING. *Le Partage politique de l'Afrique*. Brussels, 1888.—COMTE CHARLES DE KINSKY. *Le Continent Africain; Manuel de Diplomate*. Paris, 1897.—ORTROY. *Conventions Internationales . . . en Afrique*. Brussels, 1898.—SIR HARRY JOHNSTON. *Colonization of Africa*. Cambridge, 1899.—REEVES. *International Beginnings of Congo Free State*. Baltimore, 1894.—JUNO. *Deutsche Kolonien*. Leipsig, 1884.—FABRI. *Fünf Jahre Deutscher Kolonialpolitik*. Gotha, 1889.—DEMAY. *Histoire de la Colonisation Allemande*. Paris, 1890.—DESCHAMPS. *Histoire de la Question Coloniale en France*. Paris, 1891.—ALIS. *À la Conquête du Tchad*. Paris, 1891.—CARON. *De Saint-Louis au port de Tombouktou*. Paris, 1891.—CHANES. *Conquête Algérienne*. Paris, 1892.—BINGER. *Du Niger au Golfe de Guinée par le pays de Kong et le Mossi*. Paris, 1892.—M'DERMOTT. *British East Africa*. London, 1893.—LUGARD. *The Rise of our East African Empire*. London, 1893.—LUCAS. *Historical Geography of the British Colonies*. Oxford 1894, *et seq.*—PETIT. *Organisation des colonies françaises et des pays de protectorat*. Paris, 1894.

(J. S. K.)

Africa, South. See SOUTH AFRICA.

Africa, Central. See CENTRAL AFRICA.

Africa, East. See EAST AFRICA.

Aga Khan I., HIS HIGHNESS THE (1800-1881), was the title accorded by general consent to HASAN ALI SHAH (born in Persia, 1800), when, in early life, he first settled in Bombay under the protection of the British Government. He was believed to have descended in direct line from Ali by his wife Fatima, the daughter of the Prophet Mahommed. Ali's son, Hoosein, having married a daughter of one of the rulers of Persia before the time of Mahommed, the Aga Khan traced his descent from the royal house of Persia from the most remote, almost prehistoric, times. His ancestors had also ruled in Egypt as Khalifs of the Beni-Fatamites for a number of years at a period coeval with the Crusades. Before the Aga Khan emigrated from Persia he was appointed by the Emperor Fateh Ali Shah to be governor-general of the extensive and important province of Kerman. His rule was noted for firmness, moderation, and high political sagacity, and he succeeded for a long time in retaining the friendship and confidence of his master the Shah, although his career was beset with political intrigues and jealousy on the part of rival and court favourites and with internal turbulence. At last, however, the fate usual to statesmen in oriental countries overtook him, and he incurred the mortal displeasure of Fateh Ali Shah. He flew from Persia and sought protection in British territory, preferring to settle down eventually in India, making Bombay his headquarters. At that period the first Afghan War was at its height, and in crossing over from Persia through Afghanistan the Aga Khan found opportunities of rendering valuable services to the British army, and thus cast in his lot for ever with the British. A few years later he rendered similar conspicuous services in the course of the Scinde campaign, when his help was utilized by Napier in the process of subduing the frontier tribes, a large number of whom acknowledged the Aga's authority as their spiritual head. Napier held his Moslem ally in great esteem, and entertained a very high opinion of his political acumen and chivalry as a leader and soldier. The Aga Khan reciprocated the distinguished British commander's confidence and friendship by giving repeated proofs of his devotion and attachment to the British Government, and when he finally settled down in India, his position as the leader of the large Ismailiah section of Mahommedan British subjects was recognized by the Government, and the title of His Highness was conferred on him, with a large pension. From that time until his death in 1881, the Aga Khan, while leading the life of a peaceful and peacemaking citizen, under the protection of British rule, continued to discharge his sacerdotal functions, not only among his followers in India, but towards the more numerous communities which acknowledged his religious sway in distant countries such as Afghanistan, Khorassan, Persia, Arabia, Central Asia, and even distant Syria and Morocco. He remained throughout unflinchingly loyal to the British *Raj*, and by his vast and unquestioned influence among the frontier tribes on the northern borders of India he exercised a control over their unruly and wild passions in times of trouble, which proved of invaluable service in the several expeditions led by British arms on the north-west frontier of India. He was also the means of checking the fanaticism of the more turbulent Mahommedans in British India, which in times of internal troubles and misunderstandings finds vent in the shape of religious or political riots.

He was succeeded by his eldest son, AGA KHAN II. This prince continued the traditions and work of his father in a manner that won the approbation of the local Government, and earned for him the distinction of a knighthood of the order of the Indian Empire, and a seat in the Legislative Council of Bombay.

AGA KHAN III. (Sultan Mahommed Shah), only son of the foregoing, succeeded him on his death in 1885, and is the present head of the family and its devotees. He was born in 1877, and, under the fostering care of his mother, a daughter of the ruling house of Persia, has been given not only that religious and oriental education which his position as the religious leader of the Ismailiahs made indispensable, but a sound European training, a boon denied to his father and grandfather. This blending of the two systems of education has produced the happy result of fitting this Moslem chief in an eminent degree both for the sacerdotal functions which appertain to his spiritual position, and for those social duties of a great and enlightened leader which he is called upon to discharge by virtue of that position. He has travelled in distant parts of the world to receive the homage of his followers, and with the object either of settling differences or of advancing their welfare by pecuniary help and personal advice and guidance. The distinction of a Knight Commander of the Indian Empire was conferred upon him by Queen Victoria in 1897, and he has received like recognition for his public services from the German Emperor, the Sultan of Turkey, the Shah of Persia, and other potentates.

(M. M. BH.)

Agades. See SAHARA.

Agassiz, Alexander (Emanuel) (1835-——), American scientist, son of Louis Agassiz, was born in Neuchâtel, Switzerland, 17th December 1835. He came to the United States with his father in 1846; graduated at Harvard in 1855, subsequently studying engineering and chemistry, and taking the degree of bachelor of science at the Lawrence Scientific School of the same institution in 1857; taught for a time in his father's school for girls in Cambridge; and in 1859 entered upon his scientific career by becoming an assistant in the United States Coast Survey. Thenceforward he became a specialist in marine ichthyology, but devoted much time to the investigation, superintendence, and exploitation of mines, being superintendent of the Calumet and Hecla copper mines, Lake Superior (the richest in the world) from 1866 to 1869, and afterwards, as a stockholder, acquiring a fortune, out of which he gave to Harvard, for the Museum of Comparative Zoology and other purposes, some $500,000. In 1875 he surveyed Lake Titicaca, Peru; examined the copper mines of Peru and Chile; and made a collection of Peruvian antiquities for the museum, in which he had been an assistant, under his father, from time to time, and of which he was curator 1874-85, when he resigned. He assisted Sir Wyville Thomson in the examination and classification of the collections of the *Challenger* exploring expedition, and wrote the *Review of the Echini* (2 vols., 1872-74) in the reports. Between 1877 and 1880 he took part in the three dredging expeditions of the steamer *Blake*, of the United States Coast Survey, and presented a full account of them in two volumes (1888). Of his other writings on marine zoology most are contained in the bulletins and memoirs of the Museum of Comparative Zoology; but he published in 1865 (with Elizabeth Cary Agassiz, his father's wife) *Seaside Studies in Natural History*, a work at once exact and stimulating, and in 1871 a volume on the *Marine Animals of Massachusetts Bay*.

Agen, chief town of department Lot-et-Garonne, France, 380 miles S.S.W. of Paris, on railway from Bordeaux to Cette. The Garonne is here crossed by a suspension and two stone bridges; one of the latter, a fine structure of twenty-three arches, carries the lateral canal. Amongst the public buildings are the cathedral of St Caprais (who introduced Christianity in the 3rd century), parts of which date from the 12th and 13th centuries, and the ancient church of the Jacobins. The industries include the manufacture of drugs and pottery, and there are phosphate and dye works. Agen is noted for fine prunes, in which, as well also in other fruits, it carries on considerable trade. It was the birthplace of Joseph Scaliger the philologist, the naturalist Lacepède, and the poet Jacques Boé, better known as Jasmin. Population (1881), 17,098; (1891), 18,463; (1896), 18,389.

Aggregation, States of. See CONDENSATION OF GASES.

Agira, formerly SAN FILIPPO D'ARGIRÒ, a town of the province of Catania, Sicily, Italy, 9 miles S.E. from Nicosia, standing 2133 ft. above sea-level, with sulphur mines and flour-mills. It is the ancient *Argyrium*, one of the oldest of the Sikelian towns, and was colonized by Timoleon, the liberator of Syracuse, in 339 B.C. It was the birthplace of the historian Diodorus Siculus (1st cent. B.C.). Population 13,498 (1881); 17,749 (1901).

Agnew, David Hayes (1818-1892), American surgeon, was born in Lancaster county, Pennsylvania, on 24th November 1818. He graduated from the medical department of the University of Pennsylvania in 1838, and a few years later set up in practice at Philadelphia and became a lecturer at the Philadelphia School of Anatomy. He was appointed surgeon at the Philadelphia Hospital in 1854, and was the founder of its pathological museum. For twenty-six years (1863-89) he was connected with the medical faculty of the University of Pennsylvania, being elected professor of operative surgery in 1870 and professor of the principles and practice of surgery in the following year. From 1865 to 1884—except for a brief interval—he was a surgeon at the Pennsylvania Hospital. During the American Civil War he was consulting surgeon in the Mower Army Hospital, near Philadelphia, and acquired considerable reputation for his operations in cases of gun-shot wounds. He attended as operating surgeon when President Garfield was fatally wounded by the bullet of an assassin in 1881. He was the author of several works, the most important one being a three-volume, *The Principles and Practice of Surgery*. He died at Philadelphia on 22nd March 1892.

Agnosticism.—The term "agnostic" was invented by Huxley in 1869 to describe the philosophical and religious attitude of those who hold that we can have scientific or real knowledge of phenomena only, and that so far as what may lie behind phenomena is concerned—God, immortality, &c.—there is no evidence which entitles us either to deny or affirm anything. The attitude itself is as old as Scepticism (*q.v.*); but the expressions "agnostic" and "agnosticism" were applied by Huxley to sum up his deductions from those contemporary developments of metaphysics with which the names of Hamilton ("the Unconditioned") and Herbert Spencer ("the Unknowable") were associated; and it is important, therefore, to fix precisely his own intellectual standpoint in the matter. Though Huxley only began to use the term "agnostic" in 1869, his opinions had taken shape some time before that date. In a letter to Charles Kingsley (23rd September 1860) he wrote very fully concerning his beliefs:—

> I neither affirm nor deny the immortality of man. I see no reason for believing it, but, on the other hand, I have no means of disproving it. I have no *a priori* objections to the doctrine. No man who has to deal daily and hourly with nature can trouble himself about *a priori* difficulties. Give me such evidence as would justify me in believing in anything else, and I will believe that. Why should I not? It is not half so wonderful as the conservation of force or the indestructibility of matter. . . .
>
> It is no use to talk to me of analogies and probabilities. I know what I mean when I say I believe in the law of the inverse squares, and I will not rest my life and my hopes upon weaker convictions. . . .
>
> That my personality is the surest thing I know may be true. But the attempt to conceive what it is leads me into mere verbal subtleties. I have champed up all that chaff about the ego and the non-ego, noumena and phenomena, and all the rest of it, too often not to know that in attempting even to think of these

questions, the human intellect flounders at once out of its depth.

And again, to the same correspondent, 5th May 1863:—

> I have never had the least sympathy with the *a priori* reasons against orthodoxy, and I have by nature and disposition the greatest possible antipathy to all the atheistic and infidel school. Nevertheless I know that I am, in spite of myself, exactly what the Christian would call, and, so far as I can see, is justified in calling, atheist and infidel. I cannot see one shadow or tittle of evidence that the great unknown underlying the phenomenon of the universe stands to us in the relation of a Father—loves us and cares for us as Christianity asserts. So with regard to the other great Christian dogmas, immortality of soul and future state of rewards and punishments, what possible objection can I—who am compelled perforce to believe in the immortality of what we call Matter and Force, and in a very unmistakable *present* state of rewards and punishments for our deeds—have to these doctrines? Give me a scintilla of evidence, and I am ready to jump at them.

Of the origin of the name "agnostic" to cover this attitude, Huxley gave (*Coll. Ess.* v. pp. 237-239) the following account:—

> When I reached intellectual maturity, and began to ask myself whether I was an atheist, a theist, or a pantheist, a materialist or an idealist, a Christian or a freethinker, I found that the more I learned and reflected, the less ready was the answer. The one thing on which most of these good people were agreed was the one thing in which I differed from them. They were quite sure they had attained a certain "gnosis"—had more or less successfully solved the problem of existence; while I was quite sure that I had not, and had a pretty strong conviction that the problem was insoluble. This was my situation when I had the good fortune to find a place among the members of that remarkable confraternity of antagonists, the Metaphysical Society. Every variety of philosophical and theological opinion was represented there; most of my colleagues were *-ists* of one sort or another; and I, the man without a rag of a belief to cover himself with, could not fail to have some of the uneasy feelings which must have beset the historical fox when, after leaving the trap in which his tail remained, he presented himself to his normally elongated companions. So I took thought, and invented what I conceived to be the appropriate title of "agnostic." It came into my head as suggestively antithetic to the "gnostic" of Church history, who professed to know so much about the very things of which I was ignorant. To my great satisfaction the term took.

This account is confirmed by R. H. Hutton, who in 1881 wrote that the word "was suggested by Huxley at a meeting held previous to the formation of the now defunct Metaphysical Society at Mr. Knowles's house on Clapham Common in 1869, in my hearing. He took it from St. Paul's mention of the altar to the Unknown God." Hutton here gives a variant etymology for the word, which may be therefore taken as partly derived from ἄγνωστος (the "unknown" God), and partly from an antithesis to Gnostic; but the meaning remains the same in either case. The name, as Huxley said, "took"; it was constantly used by Hutton in the *Spectator*, and became a fashionable label for contemporary unbelief in Christian dogma, particularly during the 'seventies and 'eighties. Hutton himself frequently misrepresented the doctrine by describing it as "belief in an unknown and unknowable God"; but agnosticism as defined by Huxley meant not belief, but absence of belief, as much distinct from belief on the one hand as from disbelief on the other; it was the half-way house between the two, where all questions were "open." All that Huxley asked for was evidence, either for or against; but this he believed it impossible to get. Occasionally he too mis-stated the meaning of the word he had invented, and described agnosticism as meaning "that a man shall not say he knows or believes what he has no scientific ground for professing to know or believe." But as the late Rev. A. W. Momerie remarked, this would merely be "a definition of honesty; in that sense we ought all to be agnostics." Agnosticism really stands or falls by the doctrine of the Unknowable, the assertion that concerning certain objects—among them the Deity—we never can have any "scientific" ground for belief. In the 'seventies and 'eighties this way of solving, or rather passing over, the ultimate problems of thought had many followers in cultured circles imbued with the new science of the day, and with disgust for the dogmatic creeds of contemporary orthodoxy; and its outspoken and even aggressive vindication by physicists of the eminence of Huxley had a potent influence upon the attitude taken towards metaphysics, and upon the form which subsequent Christian apologetics adopted. As a nickname the term agnostic was soon misused to cover any and every variation of scepticism, and just as popular preachers confused it with atheism in their denunciations, so the callow freethinker—following Tennyson's path of "honest doubt"—classed himself with the agnostics, even while he combined an instinctively Christian theism with a facile rejection of the historical evidences for Christianity.

Huxley's agnosticism was a natural consequence of the intellectual and philosophical conditions of the 'sixties, when clerical intolerance was trying to excommunicate scientific discovery because it appeared to clash with the book of Genesis. But as the theory of evolution did its work, a new spirit was gradually introduced into Christian theology, which has turned the controversies between religion and science into other channels, and taken most of the wind out of the sails of agnosticism. A similar effect has been produced by the philosophical reaction against Herbert Spencer, and by the perception that the canons of evidence required in physical science must not be exalted into universal rules of thought. It does not follow that justification by faith must be eliminated in spiritual matters, where sight cannot follow, because the physicist's duty and success lie in pinning belief solely on verification by physical phenomena, when they alone are in question; and for mankind generally, though possibly not for an exceptional man like Huxley, an impotent suspension of judgment on such issues as a future life or the Being of God is both unsatisfying and demoralizing.

It is impossible here to do more than indicate the path out of the difficulties raised by Huxley in the letter to Kingsley quoted above. They involve an elaborate discussion, not only of Christian evidences, but of the entire subject-matter alike of Ethics and Metaphysics, of Philosophy as a whole, and of the philosophies of individual writers who have dealt in their different ways with the problems of existence and epistemology. It is, however, permissible to point out that, as has been exhaustively argued by Professor J. Ward in his Gifford lectures for 1896-98 (*Naturalism and Agnosticism*, published by A. & C. Black, 1899, London), Huxley's challenge ("I know what I mean when I say I believe in the law of the inverse squares, and I will not rest my life and my hopes upon weaker convictions") is one which a spiritualistic philosophy need not shrink from accepting at the hands of naturalistic agnosticism. If, as Huxley admits, even putting it with unnecessary force against himself, "the immortality of man is not half so wonderful as the conservation of force or the indestructibility of matter," the question then is, how far a critical analysis of our belief in the last-named doctrines will leave us in a position to regard them as the last stage in systematic thinking. It is the pitfall of physical science, immersed as its students are apt to be in problems dealing with tangible facts in the world of experience, that there is a tendency among them to claim a superior status of objective reality and finality for the laws to which their data are found to conform. But these generalizations are not ultimate truths, when we have to consider the nature of experience itself. "Because reference to the Deity will not serve for a physical explanation in physics, or a chemical explanation in chemistry, it does not therefore follow," as Professor Ward says (*op. cit.* vol. i. p. 24), "that the sum total of scientific knowledge is equally intelligible whether we accept the theistic hypothesis or not. It is true that every item of scientific knowledge is concerned with some definite relation of definite phenomena, and with nothing else; but, for all that, the systematic organization of such items may quite well yield further knowledge, which transcends the special relations of definite phenomena." At the opening of the era of modern scientific discovery, with all its fruitful new generalizations, the still more highly generalized laws of epistemology and of the spiritual constitution of man might well baffle the physicist and lead his intellect to "flounder"; but Logic too is capable of advancing, and with a superior Logic the new premisses supplied by the revelations of science are not inconclusive to those who patiently follow truth.

Agony. See Dahomey.

Agordat. See Eritrea.

Agosta. See Augusta.

Agra, a city of British India, in the North-west Provinces, which also gives its name to a district and a division. The city, on the right bank of the Jumna, 841 miles from Calcutta, is now an important railway centre, whence two main lines diverge southwards towards Bombay. In 1872 the population was 149,008; in 1881 it was 160,203; in 1891 it was 168,662; in 1901 it was 188,300, showing an increase of 12 per cent. The death-rate in 1897 was 52 per thousand. It has 2 cotton mills, with 24,450 spindles, employing 1200 hands; 7 factories for ginning and pressing cotton; a tannery and boot factory; flour mill; 48 printing presses. In 1896-97 the government college had 194 students. There are also two missionary colleges. The native town is well laid out and handsomely built. Only a small garrison is now kept in the cantonment. The municipality consists of 34 members, of whom 24 are elected, with the magistrate as *ex officio* chairman. The water-works provide a daily consumption of 1,338,000 gallons, being 8 gallons per head in the town, and 11½ gallons in the cantonment. The municipal income in 1896-97 amounted to Rs.3,82,388.

The district of Agra is traversed by several lines of railway, and part of it is irrigated by the Agra Canal. Land revenue and rates (1896-97) amounted to Rs.19,74,298, the incidence of assessment being R.1:12 per acre; the cultivated area was 683,111 acres, of which 313,728 were irrigated from wells, &c.; the number of police was 3753; of vernacular schools, 153, with 5265 pupils; the registered death-rate in 1897 was 56 per thousand. The principal crops are millets, pulses, barley, wheat, cotton, and a little indigo. Area, 1845 square miles; population (1891), 1,003,796, being 544 persons per square mile; (1901), 1,060,546, showing an increase of 6 per cent.

The division of Agra has an area of 10,139 square miles. In 1891 the population was 4,767,759, being 470 persons per square mile. In 1901 the population was 5,248,121, showing an increase of 10 per cent., attributed to the extension of irrigation from canals. It comprises the six districts of Muttra, Agra, Farukhabad, Mainpuri, Etawah, and Etah.

Agram (Slavonic, *Zagrab*; Croatian, *Zagreb*), a municipal town of Hungary, the capital of the provinces of Croatia and Slavonia. Population (1890), 38,742; (1900), 57,930. It is the seat of an archbishop and a university. The inhabitants carry on a brisk commerce and industry, its more considerable establishments being a tobacco manufactory, the works of the Hungarian state railways, a leather manufactory, a manufactory of war articles and one of carpets, &c. The new streets, especially in the lower town, are very fine, with numerous large mansions and excellent statues. The scientific and financial institutions are rapidly acquiring a recognized status.

Agricultural Machinery.—Since 1875 there has been a marked advance in agricultural machines—not so much in the invention of machines wholly unknown prior to that time, but rather in the constant improvement of those which then existed. So gradual, however, has been the change that it is hardly possible, except in the case of the Self-binding Harvester, to point to any single invention as showing a great departure from the general lines of development, though the final results are very apparent when the simple, strong, and effective machines of to-day are compared with those of a quarter of a century ago. Under these circumstances it seems undesirable to treat the subject historically, and we shall therefore illustrate and describe one or more types of the latest machines in each important class, leaving the reader to judge for himself the extent of the advance since the article in the ninth edition of this work (vol. i. p. 311) was written.

American implement makers have gone far ahead of Europe or the United Kingdom, and the following article is accordingly written from an American standpoint, and does not represent the actual conditions in operation in more conservative countries (see, however, p. 208 below). The several classes of machines will be treated by describing them in the order in which they are used in carrying on the operations performed: 1st, ploughing; 2nd, the preparation of the seed-bed; 3rd, seeding or planting; 4th, cultivating; 5th, harvesting.

Ploughs.

Where the amount of work to be done is small, and the character of the farm does not permit the use of the riding plough, the old, familiar walking plough is still in use; but it has several serious defects. Owing to the fact that the friction between the earth and the plough is entirely a sliding friction, the character of material employed in constructing the plough, and the finish imparted to it, and also the form given to the parts, have a very important effect in determining the force required to carry on the operation; and it is in respect of these features that most of the improvements in this style of implement have been made. Instead of cast iron, left in the rough state as it comes from the mould, the mould-board is now made of steel, well tempered and highly polished, the result of which is to improve its scouring qualities, and greatly reduce the draft necessary to operate it. The use of this form of plough calls for considerable skill and strength in holding it to its work, and the attention of the inventor has been naturally turned to the production of a machine in which these objections are obviated; and on the larger farms, and where the character of the surface permits it, the *sulky* or riding plough is now generally used[1] (see Fig. 1).

In this form of plough the frame is mounted on three wheels, one of which runs on the land, and the other two in the furrow. The furrow wheels are placed on inclined axles, the plough beam being carried on swinging links, operated by a hand lever, when it is necessary to raise the plough out of the furrow. The land wheel and the forward furrow wheel are adjustable vertically with reference to the frame, for the purpose of controlling the action of the plough. The team is hitched to a clevis at the end of the plough beam, and the machine is guided by a pole secured to an arm on the upper end of the spindle of the forward furrow wheel; and, by means of a connexion between this arm and a controlling arm on the spindle of the rear wheel, the latter is controlled in turning by the former.

---

[1] *Sulky* machines for tilling the soil are not used in the United Kingdom. The driver is not seated, in the case of ploughs, harrows, cultivators, rollers, etc.; but mowing machines, hay makers, harvesters, &c., have a seat for the driver, as in the United States.

The sulky plough has important advantages over the walking plough from the fact that the weight and downward pull due to its action on the ground are taken by the wheels, and the friction, being thus converted from sliding into rolling friction, is much less, and the draft is correspondingly diminished. It is also easily guided, and the depth of the furrow is readily controlled by the levers, which are assisted in their action by springs, thus greatly lightening the labour. The walking plough also possessed a serious defect on account of the downward pressure on the bottom of the furrow, which not only added to the friction, but had the effect of forming a hard and smooth bottom, which served to turn water, causing it to run along the bed thus formed and wash away the fertile soil. This was remedied to some extent by the sulky plough, as the bottom pressure was taken up by the wheels; but a form of plough intended to overcome this defect is being introduced into extensive use.

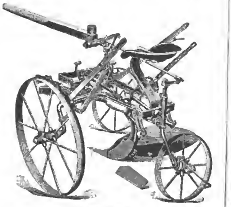


Fig. 1.—Sulky plough.

This plough is built both as a riding and a walking plough, and is shown in Fig. 2. The essential feature is the substitution of a concavo-convex disk, pivoted on the plough beam, for the mould-board and share of the ordinary plough. This disk is carried on an axle inclined to the line of draft, and also to a vertical plane. As the machine is drawn forward the disk turns on its axis and cuts deeply into the ground, and, by reason of its inclination, crowds the earth outwards and thus turns a furrow. A scraper is provided to keep the disk clean and prevent sticking, and a small plough in the rear squares the corner of the furrow. The controlling levers and draft arrangements are similar to those already described in connexion with the sulky plough. The advantage of this plough over the ordinary form is in the absence of sliding friction, and in the mellow and porous condition in which it leaves the bottom of the furrow.

Variations in soil and in the character of the surface of farming lands have led to various modifications of the plough to suit it to these different conditions. In cases where the soil is hard and clayey, it is desirable to plough deeper than usual, and for this purpose a subsoiling plough is used, which does not turn a furrow, but digs deeply into the ground and thoroughly stirs it.

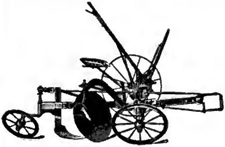


Fig. 2.—Disk plough.

Where a hillside is to be worked, a swivel plough (Fig. 3) is used. In this machine the mould-board is symmetrical about a line drawn from its point to the middle of its rear end, and is pivoted at its front and rear to the landside, so that it can be swung underneath from one side to the other, and thus changed from right to left hand, in order that the furrow may be always turned down hill.

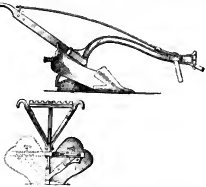


Fig. 3.—Swivel plough.

Preparation of the Seed-Bed.

The ground having been ploughed, it becomes necessary to pulverize it and break up the clods to furnish a good seed-bed, and for this purpose the harrow is used.

Harrows.—The oldest and simplest form of harrow consisted of a frame of wood, having on its under side a number of teeth, which, as the implement was drawn over the ploughed field, combed or raked the surface until it was substantially level. The first step in improving this harrow consisted in building the frame of steel bars and forming them in two or more sections secured to a common draft bar by flexible connexions, thus enabling the harrow to accommodate itself more exactly to the inequalities of the ground, and to secure a more perfect result. A harrow of this type is shown in Fig. 4.

In this machine the teeth are secured to bars pivoted at their ends in the side bars of the frame, and provided with crank arms connected to a common link bar, which may be moved horizontally by means of a lever for the purpose of adjusting the angle which the teeth make with the ground, and thus convert the machine from a pulverizer to a smoothing harrow. The small figure illustrates a spring connexion between the adjusting lever and its locking bar, which allows the teeth to yield upon striking an obstruction.

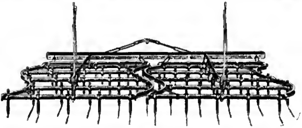
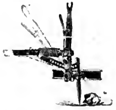


Fig. 4.—Harrow.


Showing tooth mechanism of harrow.

The course of improvement of the harrow has been much the same as in the plough, *i.e.*, in so constructing it that the operator may ride and control its movements with ease from his seat on the machine.

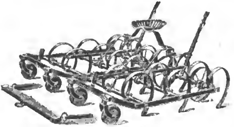


Fig. 5.—Spring-tooth harrow.

Fig. 5 illustrates a spring-tooth harrow arranged for riding. In this harrow the independent frames are carried upon wheels, and a seat for the operator is mounted upon standards supported by the two frames. The teeth consist of flat steel springs of scroll form, which yield to rigid obstructions, and are mounted on rock shafts in the same manner as in the walking harrow before described. The levers enable the operator to raise the teeth more or less, and thus free them from trash, and also regulate the depth of action.

The next improvement of the harrow is illustrated in Fig. 6.

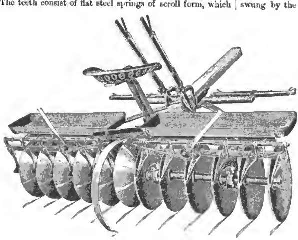


Fig. 6.—Disk harrow.

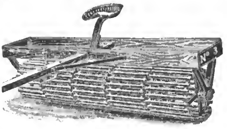


Fig. 7.—Roller pulverizer.

This machine consists of a main frame, having a pole and whiffle-trees attached, and to this frame are pivoted, near their outer ends, two supplemental frames, each of which has mounted therein a shaft carrying a series of concavo-convex disks. The supplemental frames may be swung by the adjusting levers to any angle with relation to the line of draft, and the disks then act like that of the disk plough, throwing the soil outward with more or less force, according to the angle at which they are set, and thus thoroughly breaking up and pulverizing the clods. Above the disks is a bar to which are pivoted a series of scrapers, one for each disk, which are held to their work with a yielding action, being thrown out of operation when desired by the levers shown in connexion with the operating bar. The pans on the main frame are used to carry weights to hold the disks down to their work.

For the purpose of more thoroughly pulverizing the soil, a roller is frequently used, and an improved form of this implement is shown in Fig. 7.

It consists of a set of skeleton rollers carried on a shaft, and revolving freely in such a manner that the longitudinal bars break up all lumps as the roller passes over them.

One of the hardest and most disagreeable tasks of the farmer is the hauling and distribution of manure and fertilizers; and for the purpose of lightening his labours in this respect a machine has been produced (see Fig. 8).

It consists of a waggon, the bottom of which is formed by a travelling bed or apron driven by suitable connexions with the wheels of the waggon. At the rear is mounted a revolving spiked drum or cylinder, which tears up and distributes the fertilizer as it is fed by the apron.

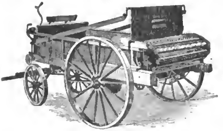


Fig. 8.—Fertilizer distributor.

Seeders and Planters.

The soil having been prepared, the next step is to sow the seed, and this is done either by broadcasting, drilling, or planting in hills.

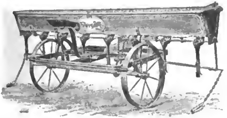


Fig. 9.—Broadcast seeder.

The broadcast seeder (see Fig. 9) consists of a wheeled frame carrying transversely thereto a seed-box having a number of seed-cups in its bottom into which the seed falls, and extending through these cups is a shaft carrying feed-wheels, one for each seed-cup. These feed-wheels are similar to a common spur gear, and serve to feed the seed regularly and deposit it in the downwardly extending tubes, where it falls upon an inclined plate and is scattered in all directions. The feed-shaft is made longitudinally adjustable, and draws the feed-wheels in or out through a revolving washer in the side of the feed-cups, thus exposing more or less of the width of the teeth and regulating the quantity of seed carried thereby.

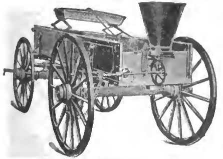


Fig. 10.—Broadcast seeder.

A very convenient and cheap form of broadcast seeder is shown in Fig 10.

This machine consists of a seed-hopper, mounted on a special tail-board, which can be substituted for the one generally used by the farmer on his waggon; a driving shaft, also mounted thereon and connected by a sprocket-chain with a sprocket-wheel on one of the rear wheels of the waggon; a rotating seed-plate in the bottom of the hopper; and a distributing wheel, shaped much like a windmill, upon which the grain falls. The seed is very effectively scattered from the distributing wheel by centrifugal force.

Machines used for drilling the seed in rows are substantially like the broadcast seeder, except that the seed falls from the tubes into a boot, as illustrated in Fig. 11.

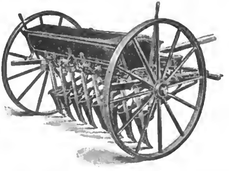


Fig. 11.—Grain drill.

Each of these boots is carried on an arm hinged at its forward end to the main frame, and provided at its lower end with a hoe, which makes a shallow furrow for the seed.

In some of the latest machines other forms of furrow-making devices are substituted for the hoes, and two of these variations are illustrated in Figs. 12 and 13.

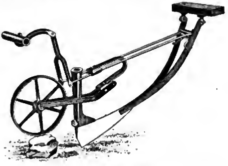


Fig. 12.—Shoe furrower.

In Fig. 12 the furrow is formed by a shoe consisting of two plates converging at their forward ends, and spaced apart immediately beneath the boot, through which the seed falls into the furrow.

In Fig. 13 the furrowing tool is the concavo-convex disk, set at an angle to the line of draft as in the disk plough, and the seed is dropped into a space formed between the disk and a flat plate secured to the lower end of the boot and bearing against the concave face of the disk.

In the United States the maize or Indian-corn crop[1] exceeds all others in value, and machines used in planting and handling this crop are of great importance. Corn (maize) is sometimes listed or planted in a continuous row like wheat, and for this purpose a machine known as a lister is employed, which is shown in Fig. 14.

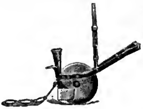


Fig. 13.—Disk furrower.

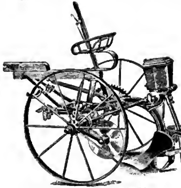


Fig. 14.—Maize lister.

In its general construction this machine is a sulky plough, having a double mould-board, which turns the furrow in both directions. Immediately behind the plough is a sub-soiler for deepening the furrow and penetrating to the moist soil below the surface. A seed-box is mounted on the plough beam, and is provided with a feed-plate operated by a shaft geared to one of the wheels. The seed is delivered to the furrow in rear of the sub-soiler and covered by two shovels which turn the soil back into the furrow.

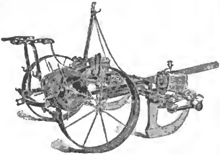


Fig. 15.—Check row corn planter.

It is, however, more common to plant maize in hills, which are spaced equally from each other and form rows in both directions, so that a cultivator may be driven between them. This work is done by a machine called a check row corn planter, shown in Fig. 15.

In using the corn planter, a wire, having buttons attached thereto, at intervals corresponding to the distance between the hills, is first stretched across the field and anchored at its ends. This wire is then placed upon the guide rollers at the side of the machine and passes between the jaws of a forked lever, which is connected at its other end with a rock-shaft passing across the machine and serving to oscillate a feed-plate in the bottom of each seed-hopper. As the buttons on the check-wire strike the forked lever, the latter is drawn to the rear and causes the feed-plate to drop the seed through the tubes into the open space between the plates of the furrowing shoe. The reel at the rear of the machine is used to take up the check-wire as the planter progresses.

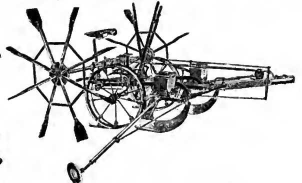


Fig. 16.—Check row corn planter.

In one of the latest corn planters, shown in Fig. 16, the check-wire is dispensed with, and the machine is provided with a shaft carrying two reels, the blades of which are at a distance apart equal to the distance between the hills of corn, and thus measure the intervals at which the corn is to be dropped. A rod, extending from the side of the machine, and carrying a small wheel, marks the next row and serves as a guide to the driver.

Potatoes are also planted by a special machine, which may be seen in Fig. 17.

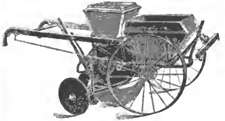


Fig. 17.—Potato planter.

The potato planter consists of a frame mounted on wheels, carrying a seed-box and usually a receptacle for fertilizers. The potatoes are fed by a suitable valve-plate into a chamber in which revolves a wheel having at the extremities of its spokes pins which impale the potatoes one by one, and carry them over to the seed tube, through which they fall into the furrow opened for them by a shoe, in the same manner as in the corn planter. An endless apron feeds the fertilizer and drops it with the potatoes, the furrow being closed by a pair of disks which follow the seed tube.

---

[1] In America the word "corn" usually signifies maize, not wheat—as in the United Kingdom—and so throughout this article. As a grain crop maize can only be grown in Europe in the southern parts and in the Danube valley.

Cultivators and Weeders.

It is important, after the seed has been planted and sprouted, to keep the ground in a porous condition, in order that it may absorb and retain moisture, and be easy of penetration by the growing roots. This result is attained by the use of cultivators, and their construction will be easily understood from Fig. 18.

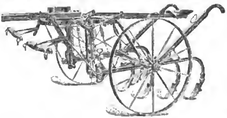


FIG. 18.—Cultivator.

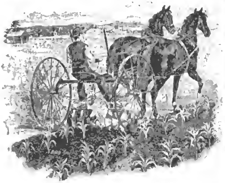


FIG. 19.—Disk cultivator.

These machines are made as walking cultivators; but, as in all the implements before described, the tendency is to provide a machine upon which the operator may ride. The drawing shows one adapted for either mode of operation. It comprises an arched axle, to extend over the row of plants; a draft frame, secured to the axle; and a pair of cultivator frames, carrying small shovels for breaking up the soil. These cultivator frames are hinged at their forward ends to the main frame, and are supported by springs, so that they would be normally raised from the ground; but the necessary pressure is applied by the feet of the rider, or by the hands of the operator in case he is walking behind the machine.

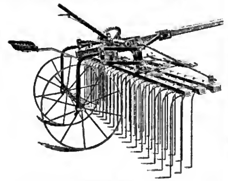


FIG. 20.—Weeder.

The latest forms of the cultivator, as shown in Fig. 19, substitute for the shovels two sets of concavo-convex disks, operating precisely as in the disk plough and harrow before mentioned.

Fig. 20 shows a new type of weeding machine now coming into use, and consisting of a wheeled frame, to which the team is attached, and from which depend a number of spring wires, whose action is to rake and tear out the weeds. A lever permits the operator to adjust the angle of the teeth with the ground.

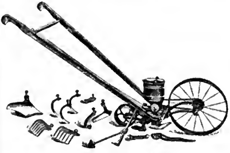


FIG. 21.—Combination implement.

In Fig. 21 is shown a very interesting implement, which is intended for gardeners, and is pushed by the operator. By changing one part for another, by simply detaching them and making the necessary substitution, the machine may be used as a hill or drill seeder and marker, a plough, a wheel hoe, a cultivator, and a harrow or rake.

Harvesters.

Mowing machines have long been in use, but have been constantly improved in construction, and the modern machine far exceeds in durability and convenience of operation that which was in use a few years ago. It is now made almost entirely of iron and steel, with very

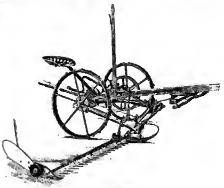


FIG. 22.—Mower.

little wood, and this construction enables all joints to be made much stronger and more permanent.

A recent form of mower is shown in Fig. 22. The cutter bar is of the well known type. The draft evener slides in guides upon the tongue, and is connected with the coupling bar in such a manner that the weight of the entire cutting apparatus is taken off the ground, thus producing a very light running machine. Levers are provided for tilting the finger bar for cutting closer or higher, and a second lever raises the coupling frame and finger bar in passing obstructions. The latter operation may also be performed by the foot of the operator pressing upon the curved lever at the rear of the axle.

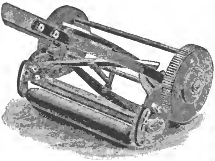


Fig. 23.—Lawn Mower.

For mowing lawns, the machine shown in Fig. 23 is used.

Instead of a reciprocating knife, the lawn mower employs a revolving reel, having spirally-arranged knives which impinge upon a stationary knife and cut the grass with a shearing action which is more effective in short and tender grass than a reciprocating knife. The gauge roller at the rear of the machine regulates the height of the cut.

Instead of raking hay by hand, the farmer now employs a horse rake, which is illustrated in Fig. 24.

The hay is raked by the spring teeth, and when a sufficient quantity to form a wind-row has accumulated, the driver presses with his foot upon a lever operating a clutch and connecting the rake head to the driving wheels. The rake is thus raised and the load dumped by the action of the team. The clearer bars, which extend rearwardly between the teeth, prevent the hay from clinging and ensure its discharge.

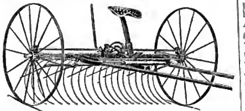


Fig. 24.—Horse rake.

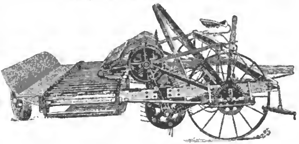


Fig. 25.—Side delivery horse rake.

In Fig. 25 is shown what is known as a side-delivery horse rake, which takes up the hay by means of a revolving toothed cylinder, from which it is taken by a toothed carrier and delivered upon a transversely moving apron. The hay is thus discharged from the machine in a continuous wind-row, extending in a direction parallel with the line of draft of the machine.

Another labour-saving machine is the tedder (Fig. 26) used for spreading and turning the hay while it is being cured.

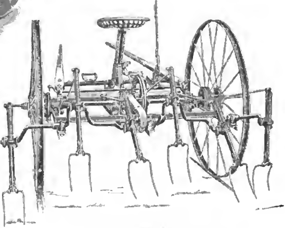


Fig. 26.—Hay tedder.

This machine is mounted on two wheels, and carries in bearings at the rear of the frame a multiple-cranked shaft, provided with a series of forks sleeved on the cranks and having their upper ends connected by links to the frame. As the crank-shaft is driven from the wheels by proper gearing the forks move upward and forward, then downward and rearward, in an elliptical path, and kick the hay sharply to the rear, thus scattering and turning it. The tedder forks are hinged to the arms and are provided with cranks connected by rods to springs on the arms, being thus enabled to yield and avoid breakage by striking an obstacle.

For loading the hay on waggons a combined hay rake and loader, shown in Fig. 27, may be used.

This machine is coupled to the rear of the hay-rack and is drawn over the field, the revolving hay rake picking up the hay and feeding it to the elevator, which consists of an endless belt driven from the wheels, and discharging the hay into the rack as it follows the machine.

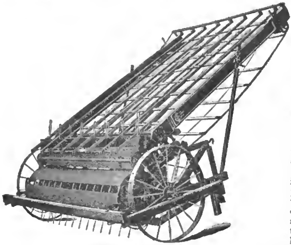


FIG. 27.—Hay rake and loader.

In storing hay in the barns the work may be done by a travelling carrier running on tracks above the hay mow, the hay being removed from the waggon by means of a harpoon fork or by slings upon which it is laid when put in the waggon. The fork or slings are attached to the pulley of the carrier, and the load is elevated and carried to the point where it is to be deposited by horse-power.

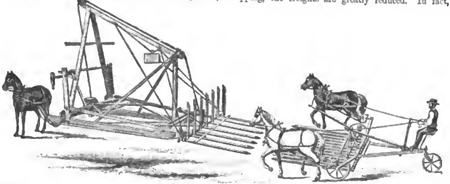


FIG. 28.—Drag rake and stacker.

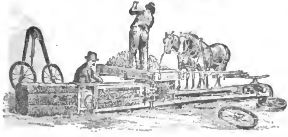


FIG. 29.—Hay baling press.

If the hay is to be stacked, a drag-rake and stacker, as shown in Fig. 28, may be employed.

The drag-rake consists of a triangular frame, having a supporting wheel at each angle, and a rake head pivoted to the frame parallel with the base of the triangle. The rake head can be lowered so that the teeth sweep the ground and take up a large quantity of hay. The rake is then driven to the stacker and the load is deposited on the elevating rake, which is hoisted by a system of pulleys and ropes, and discharges the hay on to the stack.

If hay is to be shipped it is advantageous to bale it, a press operated by horse-power (Fig. 29) being used for the purpose.

The hay-press is provided with a hopper into which the loose hay is fed in front of a plunger moved by means of a lever, to which the horses are attached. The action of the lever is then reversed, the plunger retreats, a new charge of hay is fed, and the movement is repeated. In this way the hay is pressed into a compact bale, wires are passed around it and secured, and the bale is then ejected. By treating the hay in this manner much storage space is saved, and, in shipping, the freights are greatly reduced. In fact, it would be impossible to ship hay to any distance unless it were baled.

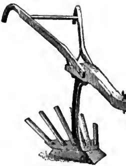


FIG. 30.—Potato digger.

Potatoes are, perhaps, most often dug by hand, but there are also machines and implements provided for this purpose.

One of the simplest of potato diggers (Fig. 30) consists of a double plough, to each wing of which are secured rearwardly extending fingers. As the plough is drawn through the field, the potatoes are thrown up, and as they slide over the fingers the loose earth is sifted through, while the potatoes fall off at the rear upon the surface of the ground, from which they are picked up by hand.

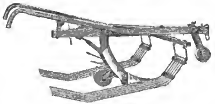


Fig. 31.—Potato digger.

A slightly different form of digger is shown in Fig. 31. This plough throws up the potatoes like the former one, but turns them off on each side, where they fall upon a floating frame composed of steel rods, which are caused to vibrate by the inequalities of the ground, sifting out the earth and leaving the potatoes on the surface.

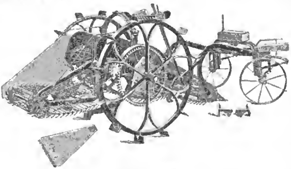


Fig. 32.—Potato digger.

A more complicated form of potato digger is shown in Fig. 32. This machine is designed to be drawn by a pair of horses, and carries at its forward end a powerful scoop, which takes up the earth and potatoes, delivering them upon an endless carrier driven from the wheels of the machine. This carrier is composed of rods, and is given a vibrating motion by which most of the earth is sifted out, and the potatoes are discharged upon a second carrier which completes the operation. The scoop can be adjusted by a suitable lever to dig at any desired depth.

Grain Harvesters.

Twenty-five years ago grain was harvested by machines, but they were very different in character from those now in use, and in no class of agricultural machines has invention made so great a change. Most of the grain was then harvested by machines cutting by a reciprocating knife and throwing the grain upon a travelling canvas apron, which delivered it to a second elevator apron carrying it over the driving wheel, where it was dropped upon a table and bound by an attendant. These machines were furnished with a divider at the end of the cutter bar for separating the grain to be cut from the standing grain, and also with a reel which pressed forward into the standing grain and pushed it back to present it properly to the cutter bar. All these are essential features of the modern harvester.

About 1873, what was probably the first commercially successful automatic self-binding harvester was brought out in the Locke wire binder. This was extensively used for several years, and wire binders were also built by other manufacturers, but there were serious objections to their use, principally on account of pieces of the wire being carried into the threshing machines and even into the flour-mills, where, by contact with the rapidly moving machinery, they were likely to cause fires.

The attention of inventors was then turned to the twine binder, but although some of the earliest attempts at grain binding were made with twine, even antedating the wire binders, it was not until 1879 that the Appleby patent, under which most of the self-binding harvesters of to-day are built, was taken out; and it was not until several years later that they came into extensive use. Some of the most important parts of the binder had been invented before the Appleby patent, such as the automatic trip which regulates the action of the binder, invented by Gray in 1858, and the knotting bill and revolving cord-holder, patented by Behel in 1864. For various reasons, however, none of these inventions went into use until they were embodied in the Appleby machine. The self-binding harvester is probably the most ingenious and interesting of all agricultural machines, and will be briefly described.

Fig. 33 shows a rear view of the self-binding harvester. As already explained, the grain is bent over and presented to the reciprocating cutter bar by means of the revolving reel, and is then conveyed by the apron and elevator over the master wheel and discharged upon the downwardly inclined binder table.

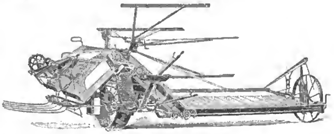


Fig. 33.—Self-binding harvester.

As the grain flows from the elevator, the butts are at the front of the machine and are evened up by a device called a butt adjuster, shown in Fig. 34, which is connected to a crank at its upper end and guided on a rod at its lower end, being thus given an elliptical movement and patting the ends of the grain, thus squaring the butt of the sheaf.

The grain moving on down the binder deck is forwarded by the packers, as seen in Fig. 35. These consist of a pair of arms sleeved upon cranks on a constantly driven shaft, and having their lower ends connected by links to the frame of the machine. By means of the packers, the grain is forced against the compressor or trip arm until a sufficient quantity has accumulated to form a bundle, the size of which is regulated by suitable adjusting devices. When the pressure on the trip arm becomes sufficient to overcome the tension of the spring, shown at the right of the figure, the latter yields, and the trip latch, being connected to the compressor shaft, is raised and releases the end of a dog carried on a gear by which the knotter shaft is driven, and the dog is immediately thrown down by a spring engaging a lug on the packer shaft. This starts the knotter shaft, which carries the compressor cam, and, the cam wheel being connected by a pitman with the needle shaft, the needle moves upward, passing the cord round the bundle. Simultaneously with the motion of the needle, the compressor is forced against the grain, and the bundle is tightly compressed between the compressor and the needle, thus taking most of the strain off the cord.

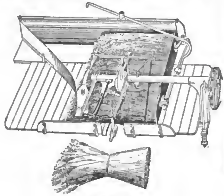


Fig. 34.—Butt adjuster.

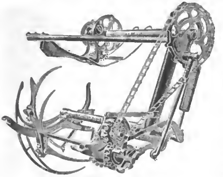


Fig. 35.—Binding mechanism.

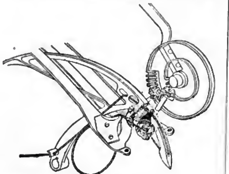


Fig. 36.—Knot-tying mechanism.

Previously to the upward movement of the needle, the cord is held by one end in the cord holder, which lies outside the knotter bill, as seen in Figs. 36 and 37, and extends over the knotter, underneath the bundle, through the eye of the needle, and thence to the twine box. As the needle carries the cord upward, the second strand is laid over the knotter and cord holder, and, at this moment, the segmental racks on the knotter wheel engage the pinions of the knotter and cord holder. As the knotter rotates, a loop of both strands of the cord is formed round both jaws, and when about three-quarters of the revolution is completed, the upper jaw is raised by a cam, the strands between the knotter and cord holder passing between the jaws and being grasped thereby. The cord-holder disk carries a knife which now strikes the cord and severs it, the end running to the eye of the needle remaining in the grasp of the holder. The discharger arms, which are rigidly secured to the knotter wheel, then reach the bundle, forcing it out of the binder, drawing off the loop from the knotter over the bight held between its jaws, and the knot is complete. All this takes place during a single revolution of the knotter shaft, and as

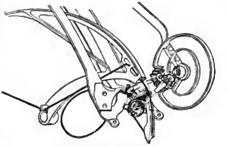


Fig. 37.—Knot-tying mechanism.

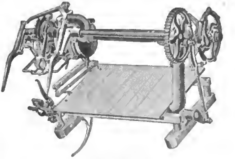


Fig. 38.—Holmes binder.

the needle retreats, the trip latch is lowered into position to strike the trip dog, thus releasing it from the lug on the packer shaft and stopping the binder until the next bundle is formed, when the action is repeated.

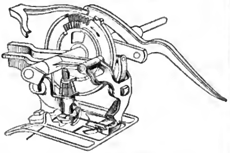


Fig. 39.—Holmes binder.

As the bundles are discharged from the binder, they are received by a bundle carrier and retained until it contains the number necessary to form a shock, when the carrier is tripped by the operator and the sheaves are deposited upon the ground. The bundle carrier is an important addition to the binder, and the cost of labour in setting the sheaves in shocks is lessened, as they are deposited in a single spot instead of being gathered from a considerable area.

The only binder built in the United States differing from the Appleby type is the Holmes binder, illustrated by Figs. 38 and 39.

This binder differs in its general organization from the Appleby, the packers being of the toothed disk type and carried above the binder table, as is also the starting clutch. The discharger is similar in construction to the forks of a tedder. The knotter is composed of two parts carried by a rotary spindle, one of them being sleeved in the other, and having an independent movement in opening and closing the jaws to receive the loop. The cord holder is of the sliding jaw type instead of the rotary form.

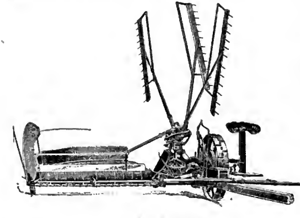


Fig. 40.—Sweep-rake reaper.

On small farms, the sweep-rake reaper shown in Fig. 40 is frequently used.

The cutting apparatus of this machine is similar to that in all harvesting machines, but is attached to the front of a quadrantal platform upon which the grain falls as it is cut. At the stubbleward end of the frame, just inside the master wheel, is a pedestal having upon its top a cam. A rotating shaft carrying a number of rake arms, hinged thereto, is mounted in the pedestal, and the rake arms are guided by the cam in such a manner that they bring the grain to the cutter bar, sweep it back over the platform, depositing it in a gavel on the ground, and are then raised abruptly to clear the driver. These cams can generally be set by a switch, so that every rake, or every second, third, or fourth rake, may deposit the gavel.

On the Pacific coast of America the wheat farms are of immense size, sometimes as large as 20,000 acres in a single field, and the climate is very dry, so that the grain is allowed to ripen in the field. These conditions have enabled American farmers to make use of headers and combined heading and threshing machines.

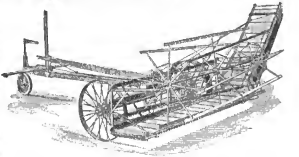


Fig. 41.—Header.

The header frame is mounted upon two wheels and has a pole extending to the rear, at the end of which is a swivelled steering wheel operated by a suitable tiller (Fig. 41). An evener is pivoted forward of the steering wheel, and to this the horses are attached and push the machine in advance. At the forward end of the frame a platform is hinged and can be adjusted vertically by means of a long lever extending back to the driver. This platform carries the cutting apparatus and the platform apron, which delivers at one side to an elevator. The cutting apparatus is adjusted to cut the heads from the grain, leaving the straw, and the heads are discharged into a waggon which moves along with the header. The header cuts a much wider swathe than the self-binder, and therefore, under the conditions to which it is adapted, is capable of doing more work.

The next step in decreasing the cost of harvesting was to combine with the header a threshing machine, the former being attached to the side of the latter, and delivering the grain thereto. The grain is then threshed out and bagged at the rate of 25 to 45 acres per day, according to the stand of grain and other varying conditions, thus reducing the cost from 6 to 9 cents per 100 pounds below that incurred when a header alone is used.

By applying a traction engine to a combined harvester, it is possible to increase the width of cut and thus add still further to its capacity. The machine shown in Fig. 42 is built with a cut as great as 42 feet, and will cut, thresh, reclean and sack 125 acres of wheat in one day, requiring eight men to operate it. It is undoubtedly the most economical machine in use for harvesting grain.

Fig. 43 illustrates a harvesting outfit consisting of engine, thresher, header, water-tank waggon, and cook-house, travelling from ranch to ranch, which gives a good idea of the scale on which this work is done.

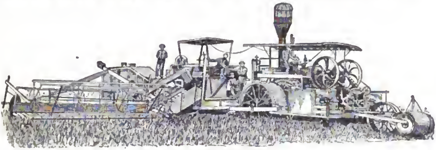


Fig. 42.—Combined steam harvester.

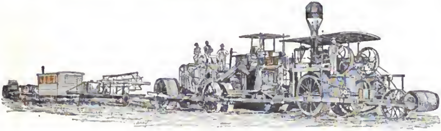


Fig. 43.—Combined harvesting outfit.

Corn Harvesters.

Until very recently, corn (maize) was harvested in America by hand, sometimes by breaking off the ears and leaving the stalks standing, and turning the cattle in to feed, and sometimes by cutting the stalks with a corn knife and securing them in shocks. Within the last few years machines have been built for performing this very laborious work. If the intention be to leave the stalks standing, a machine called a stripper and husker is used, which passes the stalks between two inclined rollers as the machine advances, the ears being snapped from the stalks by the rollers and falling on to a travelling carrier by which they are fed into a husker, and from thence to a waggon travelling with the machine. If the corn is to be shocked, a machine of the type shown in Fig. 44 is employed.

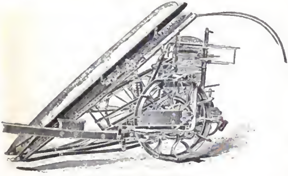


Fig. 44.—Corn harvester and binder.

In this type of corn harvester a pair of inclined gatherers passes, one on each side of the row, picking up all down stalks, and feeding them through the machine by means of the gathering chains which support them as they are cut off by the knife. The stalks are then pushed to the rear by the packers of a vertically placed automatic binder, operating in the same way as a grain binder, to bind the bundle securely and discharge it into the bundle carrier, which retains it until enough is accumulated to form a shock. The bundle carrier is then operated and deposits the bundles on the ground.

Another type of corn harvester cuts the stalks in a vertical position, as above described, but forces them over on to an inclined table, down which they slide into a horizontal binder, where they are bound in the same way as in a grain binder.

The corn having been shocked, it is now customary to feed the stalks to a husking and shredding machine, in which the ears are snapped by rollers from the stalks, and then pass on to a cylinder having a series of knives, which split the stalk and tear it into small pieces. It is finally discharged by an elevator and hauled away to be used in feeding stock. The ears of corn snapped off fall between a pair of husking rolls, which strip off the husks, the latter being carried off with the shredded stalks.

The ears of corn are then fed to a corn sheller, which rolls and rubs them between toothed disks until the kernels are detached, and they are then passed through cleaning devices in order to separate them from the chaff.

In Fig. 45 is shown a threshing machine for separating wheat and other small grain from their straw. The grain is fed between a rotating toothed cylinder and a toothed concave, by which means the straw is thoroughly beaten and the grain shaken from its husk. The straw then passes over shaking screens which shake down the grain, the latter being thoroughly cleaned by a blast of air passing upward through the screens. The straw is finally blown out through the stacking pipe on to the stack.

In conclusion, it may be said that the improvements in agricultural machinery in the last few years have made possible the opening up of vast tracts of the world's farming lands which would otherwise have remained unproductive for years to come, on account of the scarcity of labour, and have enabled agricultural operations to be carried out upon such a scale as greatly to reduce the cost of food to all the world. (R. C. S.)

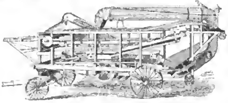


Fig. 45.—Threshing machine.

AGRICULTURE.

CONTENTS.

I. *The United Kingdom.*

General Survey: 1875-1900 . . . 178
The Acreage of Crops 181
The Produce of Crops 183
Live Stock 184
Imports of Live Animals and Meat . 185
Sale of Cattle by Live Weight . . 186
Early Maturity 187
The Breeds of Live Stock . . 188
Breed Societies 195
Maintenance of Health of Live Stock . 196
The Diseases of Animals . . . 197
The Trade in Live Stock between Ireland and Great Britain . . . 198
Exports of Animals from the United Kingdom 199
Crops and Cropping 199
The Feeding of Animals, and the Manurial Value of Different Foods . 203
Unexhausted Manure Value of Cattle Foods 206
Implements and Machinery . . 208

II. *The United States.*

Farming Statistics 209
Wheat-farming 215
Cotton 218
Cotton Seed 224
Rice 225
Flax and Hemp 225
Tobacco 225
Agricultural Education . . . 226
Agricultural Department . . . 227

LIST OF PLATES.[1]

1. Hackney Stallion, Hackney Mare.
2. Polo Pony Stallion, Shetland Pony Stallion, Yorkshire Coach Horse, Cleveland Bay Stallion.
3. Shire Stallion, Shire Mare and Foal.
4. Clydesdale Stallion, Clydesdale Filly, Suffolk Stallion, Red Polled Bull.
5. Guernsey Cow, Guernsey Bull.
6. Galloway Bull, Longhorn Bull, Sussex Bull, Welsh Bull.
7. Shorthorn Cow, Shorthorn Bull.
8. Hereford Cow, Hereford Bull, Devon Cow, Devon Bull.
9. Red Polled Bull, South Devon Bull.
10. Highland Bull, Ayrshire Cow, Aberdeen-Angus Bull, Aberdeen-Angus Cow.
11. Dexter Bull, Dexter Cow.
12. Kerry Bull, Kerry Cow, Jersey Bull, Jersey Cow.
13. Cotswold Ram, Oxford Down Ram.
14. Shropshire Ram, Lincoln Ram, Hampshire Down Ram, Southdown Ram.
15. Herdwick Ram, Kentish or Romney Marsh Ram.
16. Border Leicester Ram, Wensleydale Ram, Leicester Ram, Suffolk Wether.
17. Welsh Mountain Ram, Welsh Mountain Ewes.
18. Cheviot Ram, Dorset Horned Ram, Devon Longwool Ram, Blackfaced Mountain Ram.
19. Roscommon Ewes, Middle White Boar.
20. Large White Boar, Small White Sow, Tamworth Sow, Berkshire Boar.

GENERAL SURVEY, 1875-1900.

THE time which has elapsed since the article AGRICULTURE was published in the ninth edition of the *Encyclopædia Britannica* has been a fateful period for the greatest British industry. The hopeful views that were expressed at the conclusion of that article have not been realized. The great future that seemed then to await the application of steam power to the tillage of the soil has proved illusory. The clay soils of England, the latent fertility of which was to be brought into play in a fashion that should mightily augment the home-grown supplies of food, remain almost as intractable as ever, and the extent of land devoted to the cultivation of corn crops, instead of expanding, has diminished in a degree to which there is no recorded parallel. Farmers of long experience commonly look back to 1874 as the last of the really good years, and consider that the palmy days of British agriculture began to dwindle at about that time. The shadow of the approaching depression had already fallen upon the land before the year 1875 had run its course, and the outlook became ominous as the decade of the 'seventies neared its close. One memorable feature was associated with 1877 in that this was the last year in which the dreaded cattle plague (rinderpest) made its appearance in England. There has been no record of it in the British isles since that year, and it is hoped that it has been banished for ever. The same year, 1877, was the last also in which the annual average price of English wheat exceeded 50s. per imperial quarter. The average was 56s. 9d. that year, but it has never since been within 10s. of this level. With declining prices for farm produce came that year of unhappy memory, 1879, when persistent rains and an almost sunless summer ruined the crops, and reduced many farmers to a state of destitution. Much of the grain was never

---

[1] These portraits are not intended to convey any idea of the relative sizes of the different animals. In plate 14, for example, the Hampshire Down Ram, though represented by a smaller picture, is a decidedly bigger animal than the Southdown Ram portrayed in the same plate.

Royal commission, 1879.

harvested, whilst owing mainly to the excessive floods there commenced an outbreak of liver-rot in sheep, due to the ravages of the fluke parasite. This continued for several years, and the mortality was so great that its adverse effects upon the ovine population of the country were still perceptible ten years afterwards. A fall in rents was the necessary sequel of the agricultural distress, to inquire into which a royal commission was appointed in 1879, under the chairmanship of the duke of Richmond and Gordon. Its report, published in 1882, testified to "the great extent and intensity of the distress which has fallen upon the agricultural community. Owners and occupiers have alike suffered from it. No description of estate or tenure has been exempted. The owner in fee and the life tenant, the occupier, whether of large or of small holding, whether under lease, or custom, or agreement, or the provisions of the Agricultural Holdings Act—all without distinction have been involved in a general calamity." The two most prominent causes assigned for the depression were bad seasons and foreign competition, aggravated by the increased cost of production and the heavy losses of live stock. Abundant evidence was forthcoming as to the extent to which agriculture had been injuriously affected "by an unprecedented succession of bad seasons." As regards the pressure of foreign competition, it was stated to be greatly in excess of the anticipations of the supporters, and of the apprehensions of the opponents, of the repeal of the Corn Laws. Whereas formerly the farmer was to some extent compensated by a higher price for a smaller yield, in recent years he had had to compete with an unusually large supply at greatly reduced prices. On the other hand, he had enjoyed the advantage of an extended supply of feeding-stuffs—such as maize, linseed cake, and cotton cake—and of artificial manures, imported from abroad. The low price of agricultural produce, beneficial though it might be to the general community, had lessened the ability of the land to bear the proportion of taxation which had heretofore been imposed upon it. The legislative outcome of the findings of this royal commission was the Agricultural Holdings Act 1883, a measure which continued in force in its entirety till 1901, when a new Act came into operation.

Board of Agriculture, 1889.

The apparently hopeless outlook for corn-growing compelled farmers to cast about for some other means of subsistence, and to rely more than they had hitherto done upon the possibilities of stock-breeding. It was in particular the misfortunes of the later 'seventies that gave the needed fillip to that branch of stock-farming concerned with the production of milk, butter, and cheese, and from this period may be said to date the revival of the dairying industry, which received a powerful impetus through the introduction of the centrifugal cream separator, and was fostered by the newly-established British Dairy Farmers' Association. The generally wet character of the seasons in 1879 and the two or three years following was mainly responsible for the high prices of meat, so that the supplies of fresh beef and mutton from Australia which now began to arrive found a ready market, and the trade in imported fresh meat which was thus commenced has practically continued to expand ever since. The great losses arising from spoilt hay crops served to stimulate experimental inquiry into the method of preserving green fodder known as ensilage, with the result that the system eventually became successfully incorporated in the ordinary routine of agricultural practice. A contemporaneous effort in the direction of drying hay by artificial means led to nothing of practical importance. By 1882 the cry as to land going out of cultivation became loud and general, and the migration of the rural population into the towns in search of work continued unchecked. In 1883 foot-and-mouth disease was terribly rampant amongst the herds and flocks of Great Britain, and was far more prevalent than it has ever been since. It was about this time that the first experiments were made (in Germany) with basic slag, a material which had hitherto been regarded as a worthless by-product of steel manufacture. A year or two later field trials were begun in England, with the final result that basic slag has become recognized as a valuable source of phosphorus for growing crops, and is now in constant demand for application to the soil as a fertilizer. In 1883 the veterinary department of the Privy Council—which had been constituted in 1865 when the country was ravaged by cattle plague—was abolished by order in council, and the "Agricultural Department" was substituted, but no alteration was effected in the work of the department, so far as it related to animals. In 1889 the Board of Agriculture (for Great Britain) was formed under an Act of parliament of that year (52 & 53 Vict. c. 30), and the immediate control of the Agricultural Department was transferred from the clerk of the Privy Council to the secretary of the Board of Agriculture, where it remains. A Minister for Agriculture had for years been asked for in the interests of the agricultural community, and the functions of this office are discharged by the president of the Board of Agriculture, whose appointment of course is, like that of the president of the Board of Trade, a political one, and may or may not carry with it a seat in the Cabinet. The Board of Agriculture, on its establishment, took over from the Privy Council the responsibilities of the Contagious Diseases (Animals) Acts, besides the comprehensive duties of the Land Commission, and the authority and responsibilities of the Commissioners of Her Majesty's Works and Public Buildings under the Survey Act of 1870. The Board is entrusted with the collection and preparation of statistics relating to agriculture and forestry, the inspection of schools (not being public elementary schools) in which technical instruction is given in agriculture or forestry, and the instituting of such experimental investigations as may be deemed conducive to the progress of agriculture and forestry. The election took place in the same year (1889) of the first county councils, and the allotment to them of various sums of money under the Local Taxation (Customs and Excise) Act 1890 enabled local provision to be made for the promotion of technical instruction in agriculture. It was at about this time that the value of a mixture of lime and sulphate of copper (*bouillie bordelaise*), sprayed in solution upon the growing plants, came to be recognized as a check upon the ravages of potato disease.

The general experience of the decade of the 'eighties was that of disappointing summers, harsh winters, falling prices, declining rents, and the shrinkage of land values. It is true that one season of the series, that of 1887, was hot and droughty, but the following summer was exceedingly wet. Nevertheless the decade closed more hopefully than it opened, and found farmers taking a keener interest in grass land, in live stock, and in dairying. Cattle-breeders did well in 1889, but sheep-breeders fared better; on the other hand, owing to receding prices, corn-growers were more disheartened than ever. With the incoming of the last decade of the century there seemed to be some justifiable hopes of the dawn of better times, but they were speedily doomed to disappointment. In 1891 excessively heavy autumn rains washed the arable soils to such an extent that the next season's corn crops were below average. Wheat in particular was a poor crop in 1892, and the low yield was associated with falling prices, due to large imports. The hay crop was very inferior, and in some

Royal Commission, 1893.

cases it was practically ruined. This gave a stimulus to the trade in imported hay, which rose from 61,237 tons in 1892 to 263,050 tons in 1893, and despite some large home-grown crops in certain subsequent years (1897 and 1898) this expansion has never since been wholly lost. The misfortunes of 1892 proved to be merely a preparation for the disasters of 1893, in which year occurred the most destructive drought within living memory. Its worst effects were seen upon the light land farms of England, and so deplorable was the position that a Royal Commission on agricultural depression was appointed in September of that year under the chairmanship of Mr Shaw Lefevre. Thus, within the last quarter of the 19th century—and, as a matter of fact, only fourteen years apart—two Royal Commissions on agriculture were appointed, the one in a year of memorable flood, 1879, and the other in a year of disastrous drought, 1893. The report of the Commission of 1893 was issued in March 1896. Amongst its chief recommendations were those relating to amendments in the Agricultural Holdings Acts, and to tithe rent-charge, railway rates, damage by game, sale of adulterated products, and sale of imported goods (meat, for example) as home produce. Two legislative enactments arose out of the work of this Commission. In the majority report it was stated "that, in order to place agricultural lands in their right position as compared with other ratable properties, it is essential that they should be assessed to all local rates in a reduced proportion of their ratable value." The Agricultural Rates Act, 1896, gave effect to this recommendation. Its objects were to relieve agricultural land from half the local rates, and to provide the means of making good out of Imperial funds the deficiency in local taxation thereby caused. It was provided that the Act should continue in force only till 31st March 1902, but a further Act in 1901 extended the period by four years. Meanwhile the Royal Commission on local taxation was inquiring into the general incidence of local taxation, both urban and rural, and its proper adjustment between real and personal property, and presented its report in the summer of 1901. The other measure arising out of the report of the Royal Commission of 1893 was the Agricultural Holdings Act, 1900. This is an amending Act and not a consolidating Act; consequently it has to be read as if incorporated into the already existing Acts. As affecting agricultural practice there are three noteworthy improvements in respect of the making of which, without the consent of or notice to his landlord, a tenant may claim compensation—(1) the consumption on the holding "by horses, other than those regularly employed on the holding," of corn, cake, or other feeding-stuff not produced on the holding; (2) the "consumption on the holding by cattle, sheep, or pigs, or by horses other than those regularly employed on the holding, of corn proved by satisfactory evidence to have been produced and consumed on the holding"; (3) "laying down temporary pasture with clover, grass, lucerne, sainfoin, or other seeds sown more than two years prior to the determination of the tenancy."

Effects of Drought.

After 1894, in which year the brilliant prospects of a bountiful harvest were ultimately extinguished by untimely and heavy rains, all the remaining seasons of the closing decade of the 19th century were dominated by drought. A fact that was amply illustrated, moreover, is that the period of incidence of a drought is not less important than its duration, and the same is true of abnormal rainfall. A spring drought, a summer drought, an autumn drought, each has its distinctive characteristics in so far as the effect upon the crops is concerned. The hot drought of 1893 extended over the spring and summer months, but there was an abundant rainfall in the autumn; correspondingly there was an unprecedentedly bad yield of corn and hay crops, but a moderately fair yield of the main root crops (turnips and swedes). In 1899 the drought became most intense in the autumn, after the corn crops had been harvested, but during the chief period of growth of the root crops; correspondingly the corn crops of that year rank very well amongst the crops of the decade, but the yield of turnips and swedes was the worst on record. It is quite possible for a hot dry season to be associated with a large yield of corn, provided the drought is confined to a suitable period, as was the case in 1896, and still more so in 1898; the English wheat crops in those years were probably the biggest in yield per acre that had been harvested since 1868, which is always looked back upon as a remarkable year for wheat. The drought of 1898 was interrupted by copious rains in June, and these falling on a warm soil led to a rapid growth of grass and, as measured by yield per acre, an exceedingly heavy crop of hay.

With the exceptions of 1891 and 1894, every year in the period 1891-1900 was stricken by drought. The two meteorological events of the decade which will probably live longest in the recollection were, however, the terrible drought of 1893, resulting in a fodder famine in the succeeding winter, and the severe frost of ten weeks' duration at the beginning of 1895. Between these two occurrences came the disastrous decline in the value of grain in the autumn of 1894, when the weekly average price of English wheat fell to the record *minimum* of 17s. 6d. per imperial quarter. As a consequence, the extent of land devoted to wheat in the British isles receded in 1895 to less than 1½ million acres, which is the lowest area on record. Successful trials of sulphate of copper solution as a means of destroying charlock in corn crops took place in the years 1898-1900. Charlock is a most persistent cruciferous weed, but if sprayed when young with the solution named it is killed, the corn plants being uninjured.

Legislation.

Amongst recent legislative measures of importance to agriculturists mention should be made, in addition to those that have been referred to, of the Tithe Rent-charge Recovery Act, 1891, which transfers the liability for payment of tithe from the occupier to the owner. In the same year was passed the Markets and Fairs (Weighing of Cattle) Act. The object of the Small Holdings Act, 1892, was to facilitate the acquisition of small agricultural holdings. It provides that a county council may acquire any suitable land, with the object of allotting from one to fifty acres, or, if more than fifty acres, of an annual value not exceeding £50, to persons who desire to buy, and will themselves cultivate, the holdings. If, owing to proximity to a town or otherwise, the prospective value is too high, the council may hire such land for the purpose of letting it. The Fertilizers and Feeding Stuffs Act, 1893, compels sellers of fertilizers (*i.e.*, manures), manufactured or imported, to state the percentage of the nitrogen, of the soluble and insoluble phosphates, and of the potash in each article sold, and this statement is to have the effect of a warranty. Similar stringent conditions apply as regards the sale of feeding stuffs for live stock. The Finance Act of 1894, with its great changes in the death duties, overshadowed all other Acts of that year both in its immediate effects and in its far-reaching consequences. The Copyhold Consolidation Act, 1894, supersedes six previous copyhold statutes, but does not effect any alteration in the law concerning enfranchisement. The Diseases of Animals Act, 1896, provided for the compulsory slaughter of imported live stock at the place of landing. The Light Railways Act and the Locomotives on Highways Act were added to the Statute Book in 1896, and various clauses in the Finance Act effected reforms in respect of the death duties, the land-tax, farmers' income-tax, and the beer duty. The Chaff-cutting Machines (Accidents) Act, 1897, is a measure very similar in its intention to the Threshing Machines Act, 1878, and provides for the automatic prevention of accidents to persons in charge of chaff-cutting machines. The Sale of Food and Drugs Act, 1899, has special reference in its earlier sections to the trade in dairy produce and margarine. In 1899 was also passed the Act establishing a department of agriculture and technical instruction in Ireland.

THE ACREAGE OF CROPS.

TABLE I.—*Areas of Cereal Crops in the United Kingdom —Acres.*

Year.	Wheat.	Barley.	Oats.	Total.
1875	3,514,088	2,751,362	4,176,177	10,441,627
1880	3,065,895	2,695,000	4,191,716	9,952,611
1885	2,553,092	2,447,169	4,282,594	9,282,855
1890	2,483,595	2,300,994	4,137,790	8,922,379
1895	1,456,042	2,346,367	4,527,899	8,330,308
1900	1,901,014	2,172,140	4,145,633	8,218,787

TABLE II.—*Gazette Annual Average Prices per Imperial Quarter of British Cereals in England and Wales, 1875 to* 1900.

Year.	Wheat.		Barley.		Oats.	
	s.	d.	s.	d.	s.	d.
1875	45	2	38	5	28	8
1876	46	2	35	2	26	3
1877	58	9	39	8	25	11
1878	46	5	40	2	24	4
1879	43	10	34	0	21	9
1880	44	4	33	1	23	1
1881	45	4	31	11	21	9
1882	45	1	31	2	21	10
1883	41	7	31	10	21	5
1884	35	8	30	8	20	3
1885	32	10	30	1	20	7
1886	31	0	26	7	19	0
1887	32	6	25	4	16	3
1888	31	10	27	10	18	9
1889	29	9	25	10	17	9
1890	31	11	28	8	18	7
1891	37	0	28	2	20	0
1892	30	3	26	2	19	10
1893	26	4	25	7	18	9
1894	22	10	24	6	17	1
1895	23	1	21	11	14	6
1896	26	2	22	11	14	9
1897	30	2	23	6	16	11
1898	34	0	27	2	18	5
1899	25	8	25	7	17	0
1900	26	11	24	11	17	7

TABLE III.—*Imports into the United Kingdom of Wheat Grain, and of Wheat Meal and Flour—Cwt.*

Year.	Wheat Grain.	Meal and Flour.	Total.
1875	51,878,517	6,136,083	58,012,600
1880	55,261,924	10,558,312	65,820,236
1885	61,498,864	15,832,843	77,331,707
1890	60,474,180	15,773,336	76,247,516
1895	81,749,955	18,368,410	100,118,365
1900	68,615,990	21,542,035	90,158,025

The most notable feature in connexion with the cropping of the land of the United Kingdom during the last quarter of the 19th century was the lessened cultivation of the cereal crops, associated with an expansion in the area of grass land. At the beginning of the period the aggregate area under wheat, barley, and oats was nearly 10½ million acres; at the close it did not much exceed 8 million acres. There was thus a withdrawal during the period of considerably over 2 million acres from cereal cultivation. From Table I., showing the acreage at intervals of five years, it will be learnt that the loss fell chiefly upon the wheat crop, which at the close of the period occupied barely more than half the area assigned to it at the beginning. If the land taken from wheat had been cropped with one or both of the other cereals, the aggregate area would have remained about the same. This, however, has not been the case, for a fairly uniform decrease in the barley area has been accompanied by somewhat irregular fluctuations in the acreage of oats. To the decline in prices of home-grown cereals the decrease in area is largely attributable. The extent of this decline is seen in Table II., wherein are given the annual average prices, calculated upon returns from the statutory markets of England and Wales (numbering 196[1] since 1890, under the Corn Returns Act, 1882). These prices are per imperial quarter,—that is, 480 ℔ of wheat, 400 ℔ of barley, and 312 ℔ of oats, representing 60 ℔, 50 ℔, and 39 ℔ per bushel respectively. Since 1883 the annual average price of English *wheat* has never again been so high as 40s. per quarter, and only twice since 1892 has it exceeded 30s. In one of these exceptional years, 1898, the average rose to 34s., but this was due entirely to a couple of months of inflated prices in the early half of the year, when the outbreak of war between Spain and the United States of America coincided with a huge speculative deal in the latter country. The weekly average prices of English wheat in 1898 fluctuated between 48s. 1d. and 25s. 5d. per quarter, the former being the highest weekly average since 1882. The *minimum* annual average was 22s. 10d. in 1894, in the autumn of which year the weekly average sank to 17s. 6d. per quarter, the lowest on record. Wheat was so great a glut in the market that various methods were devised for feeding it to stock, a purpose for which it is not specially suited; in thus utilizing the grain, however, a smaller loss was often incurred than in sending it to market. In 1894 the monthly average price for October, the chief month for wheat-sowing in England, was only 17s. 8d. per quarter, and farmers naturally shrank from seeding the land freely with a crop which could not be grown except at a heavy loss. The result was that in the following year the wheat crop of the United Kingdom was harvested upon the smallest area on record,—less than 1½ million acres. In only one year of the last quarter-century, 1878, did the annual average price of English *barley* touch 40s. per quarter; it has never again reached 30s. since 1885, whilst in 1895 it fell to so low a level as 21s. 11d. The same story of declining prices applies to *oats*. An average of 20s. per quarter was touched in 1891, but with that exception this useful feeding grain has not reached that figure since 1885. In 1895 the average price of 480 ℔ of wheat, at 23s. 1d., was identical with that of 312 ℔ of oats in 1880, and it was less in the preceding year. The declining prices that have operated against the growers of wheat should be studied in conjunction with Table III., which shows, at intervals of five years, the imports of wheat grain and of wheat meal and flour into the United Kingdom. The import of the manufactured product is increasing at a much greater ratio than that of the raw grain, for whilst in 1875 the former represented less than one-ninth of the total, by 1900 the proportion had risen to nearly one-fourth. The offal, which is quite as valuable as the flour itself, is thus retained abroad instead of being utilized for stock-feeding purposes in the United Kingdom. The highest and lowest areas of wheat, barley, and oats in the United Kingdom during the period 1875-1900 were the following:—

Wheat . .	3,514,088 acres in 1875	1,456,042 acres in 1895
Barley . .	2,931,809 acres in 1879	2,068,780 acres in 1898
Oats . .	4,527,899 acres in 1895	3,998,200 acres in 1879

---

[1] Altered to 190 on 1st January 1901.

These show differences amounting to 2,058,046 acres for wheat, 863,049 acres for barley, and 529,699 acres for oats. The acreage of wheat, therefore, has fluctuated the most, and that of oats the least. Going back to 1869, it is found that the extent of wheat in that year was 3,981,989 acres, or very little short of four million acres.

The acreage of *rye* grown in the United Kingdom as a grain crop is small, the respective *maximum* and *minimum* areas during the period 1875-1900 having been 102,676 acres in 1894 and 47,937 acres in 1880. Rye is perhaps more largely grown as a green crop to be fed off by sheep, or cut green for soiling, in the spring months.

Of corn crops other than cereals, *beans* and *peas* are both less cultivated than formerly. In the period 1875-1900 the area of beans in the United Kingdom fluctuated between 574,414 acres in 1875 and 230,429 acres in 1897, and that of peas between 318,410 acres in 1875 and 163,325 acres in 1899. The area of peas has thus shrunk nearly one-half, and that of beans more than one-half. Taking cereals and pulse corn together, the aggregate areas of wheat, barley, oats, rye, beans, and peas in the United Kingdom have varied as follows over the five quinquennial intervals embraced in the period 1875-1900:—

Year.	Acres.	Year.	Acres.
1875	11,399,030	1890	9,574,249
1880	10,672,086	1895	8,865,338
1885	10,014,625	1900	8,707,602

Disregarding minor fluctuations, there has thus been a loss of corn land over the quarter-century of 2,691,639 acres, or nearly 24 per cent.

The area that has been withdrawn from corn growing is not to be found under the head of what are termed "green crops." In 1900 the total area of these crops in the United Kingdom was 4,301,774 acres, made up thus:—

Crop.	Acres.
Potatoes	1,227,569
Turnips and swedes	1,994,421
Mangel	484,050
Cabbage, kohl-rabi, and rape	242,967
Vetches or tares	181,679
Other green crops	171,088

The extreme aggregate areas of these crops during the quarter-century were 5,057,029 acres in 1875 and 4,261,441 acres in 1898. At five-year intervals the areas have been:—

Year.	Acres.	Year.	Acres.
1875	5,057,029	1890	4,534,145
1880	4,746,293	1895	4,399,949
1885	4,765,195	1900	4,301,774

These crops, therefore, which, except potatoes, are used mainly for stock-feeding, have like the corn crops been grown on gradually diminishing areas.

The land that has been lost to the plough is found to be still further augmented when an inquiry is instituted into the area devoted to clover, sainfoin, and grasses under rotation. In the period 1875-1900 this area has fluctuated between 6,557,748 acres in 1878 and 5,862,754 acres in 1894, whilst the areas at five-year intervals are given in Table IV. Under the old Norfolk or four-course rotation (roots, barley, clover, wheat) land thus seeded with clover or grass seeds was intended to be ploughed up at the end of a year. Labour difficulties, low prices of produce, bad seasons, and similar causes provided inducements for leaving the land in grass for two years, or over three years or more, before breaking it up for wheat. In many cases it would be decided to let such land remain under grass indefinitely, and thus it would no longer be enumerated in the Agricultural Returns as temporary grass land, but would pass into the category of permanent grass land, or what is often spoken of as "permanent pasture." Whilst much grass land has been laid down with the intention from the outset that it should be permanent, at the same time some considerable areas have through stress of circumstances been allowed to drift from the temporary or rotation grass area to the permanent list, and have thus still further diminished the area formerly under the dominion of the plough. The column relating to permanent grass in Table IV. shows clearly enough how the British Isles have for the last quarter-century been becoming more pastoral, whilst figures previously quoted demonstrate the extent to which they have become less arable. In the period 1875-1900 the extreme areas returned as "permanent pasture"—a term which, it should be clearly understood, does not include heath or mountain land, of which there are in Great Britain alone about thirteen million acres used for grazing—were 23,772,602 acres in 1875, and 28,261,529 acres in 1900, whilst the totals at five-year intervals are stated in Table IV. Comparing 1900 with 1875 the increase in permanent grass land is found to amount to close upon 4½ million acres, or about 19 per cent.

TABLE IV.—*Areas of Grass Land (excluding Heath and Mountain Land) in the United Kingdom—Acres.*

Year.	Temporary (*i.e.* under rotation).	Permanent (*i.e.* not broken up in rotation).	Total.
1875	6,337,953	23,772,602	30,110,555
1880	6,389,232	24,717,092	31,106,324
1885	6,738,206	25,616,071	32,354,277
1890	6,097,210	27,115,425	33,212,635
1895	6,061,139	27,831,117	33,892,256
1900	6,024,317	28,261,529	34,285,846

On account of the greater humidity and mildness of its climate Ireland is more essentially a pastoral country than Great Britain. The distribution between the two islands of such important crops of arable land as cereals and potatoes is indicated in Table V. The figures are those for 1900, but, though the absolute acreages vary somewhat from year to year, there is not much variation in the percentages. The comparative insignificance of Ireland in the case of the wheat and barley crops, represented by 2·8 and 8 per cent. respectively, receives some compensation when oats and potatoes are considered, fully one-fourth of the area of the former and more than half that of the latter being claimed by Ireland. It is noteworthy, however, that Ireland is year by year placing less reliance upon the potato crop. In 1888 the area of potatoes in Ireland was 804,566 acres, but it continuously contracted each year, until in 1900 it did not exceed 654,413 acres, or 150,153 acres less than twelve years previously.

TABLE V.—*Areas of Cereal and Potato Crops in Great Britain and Ireland in 1900.*

	Wheat.		Barley.	
	Acres.	Per Cent.	Acres.	Per Cent.
Great Britain	1,845,042	97·2	1,990,265	92
Ireland	53,797	2·8	174,006	8
Total	1,898,839	100·0	2,164,271	100
	Oats.		**Potatoes.**	
Great Britain	3,026,088	73·3	561,361	46
Ireland	1,104,848	26·7	654,413	54
Total	4,130,936	100·0	1,215,774	100

A similar comparison for the several sections of Great Britain, as instituted in Table VI., shows that to England belongs about 95 per cent. of the wheat area, over 80 per cent. of the barley area, over 60 per cent. of the oats area, and 70 per cent. of the potato area, and these proportions do not vary much from year to year. The figures for cereals are important, as they indicate that it is the farmers of England who are the chief sufferers through the diminishing prices of corn; and particularly is this true of East Anglia, where corn-growing is more largely pursued than in any other part of the country. Scotland possesses nearly one-third of the area of oats and nearly one-fourth of that of potatoes. Beans are almost entirely confined to England, and this is even more the case with peas. The mangel crop also is mainly English, the summer in most parts of Scotland being neither long enough nor warm enough to bring it to maturity.

TABLE VI.—*Areas of Cereal and Potato Crops in England, Wales, and Scotland, and in Great Britain, in 1900.*

	Wheat.		Barley.	
	Acres.	Per Cent.	Acres.	Per Cent.
England . .	1,744,556	94·6	1,645,022	82·7
Wales . .	51,654	2·8	105,048	5·3
Scotland . .	48,832	2·6	240,195	12·0
Great Britain .	1,845,042	100·0	1,990,265	100·0
	Oats.		Potatoes.	
England . .	1,860,513	61·5	396,936	70·7
Wales . .	216,447	7·1	33,225	5·9
Scotland . .	949,128	31·4	131,200	23·4
Great Britain .	3,026,088	100·0	561,361	100·0

THE PRODUCE OF CROPS.

Whilst the returns relating to the acreage of crops and the number of live stock in Great Britain have been officially collected in each year since 1866, the annual official estimates of the produce of the crops in the several sections of the kingdom do not extend back beyond 1885. The practice is for the Board of Agriculture to appoint local estimators, who report in the autumn as to the total production of the crops in the localities respectively assigned to them. By dividing the total production, say of wheat, in each county by the number of acres of wheat as returned by the occupiers at 4th June, the estimated average yield per acre is obtained. It is important to notice that the figures relating to total production and yield per acre are only *estimates*, and it is not claimed for them that they are anything more. The fact that much of the wheat to which the figures apply is still in the stack after the publication of the figures shows that the latter are essentially estimates. The total produce of any crop in a given year must depend mainly upon the acreage grown, whilst the average yield per acre will be determined chiefly by the character of the season. In Table VII. are shown, in thousands of bushels, the estimated produce of the corn crops of the United Kingdom in each of the years 1890 to 1900. The largest area of wheat in the period was that of 1890, and the smallest was that of 1895; the same two years are seen to have been respectively those of highest and lowest total produce. It is noteworthy that in 1895 the country produced little more than half as much wheat as in any one of the years 1890, 1891, and 1898. The produce of barley, like that of oats, is less irregular than that of wheat, the extremes for barley being 80,794,000 bushels and 65,746,000 bushels, and those for oats 190,863,000 bushels and 162,860,000 bushels. As to beans, the produce of 1890 was about equal to that of 1892 and 1893 together. Similar details for potatoes, roots, and hay, brought together in Table VIII., show that the production of potatoes varies much from year to year. The imports of potatoes into the United Kingdom vary, to some extent, inversely; thus, the low production in 1897 was accompanied by an increase of imports from 3,921,205 cwt. in 1897 to 6,751,728 cwt. in 1898. No very great reliance can be placed upon the figures relating to turnips (which include swedes), as these are mostly fed to sheep on the ground, so that the estimates as to yield are necessarily vague. Mangels are probably more closely estimated, as these valuable roots are carted and stored for subsequent use for feeding stock. Under hay are included the produce of clover, sainfoin, and rotation grasses, and also that of permanent meadow. The extent to which the annual production of the leading fodder crop may vary is shown in the table by the two consecutive years 1893 and 1894; from only nine million tons in the former year the production rose to upwards of fifteen million tons in the latter, an increase of fully 70 per cent.

TABLE VII.—*Estimated Annual Total Produce of Corn Crops in the United Kingdom,* 1890 *to* 1900—*Thousands of Bushels.*

Year.	Wheat.	Barley.	Oats.	Beans.	Peas.
1890	75,994	80,794	171,295	11,860	6313
1891	74,743	79,555	166,472	10,694	5777
1892	60,775	76,939	168,181	7,054	5028
1893	50,913	65,746	168,588	4,863	4756
1894	60,704	78,601	190,863	7,198	6229
1895	38,285	75,028	174,476	5,626	4732
1896	58,247	77,825	162,860	6,491	4979
1897	56,296	72,613	163,556	6,650	5250
1898	74,885	74,731	172,578	7,267	4858
1899	67,261	74,532	166,140	7,566	4131
1900	54,322	68,546	165,137	7,469	4072

TABLE VIII. — *Estimated Annual Total Produce of Potatoes, Roots, and Hay in the United Kingdom,* 1890 *to* 1900—*Thousands of Tons.*

Year.	Potatoes.	Turnips.	Mangels.	Hay.
1890	4622	32,002	6709	14,466
1891	6090	29,742	7558	12,671
1892	5634	31,419	7428	11,567
1893	6541	31,110	5225	9,082
1894	4662	30,678	7310	15,699
1895	7065	29,221	6376	12,238
1896	6263	28,037	5875	11,416
1897	4107	29,785	7379	14,043
1898	6225	26,499	7228	15,916
1899	5837	20,370	7604	12,898
1900	4577	28,387	9650	13,742

Turning to the average yields per acre, as ascertained by dividing the number of acres into the total produce, the results of a decade are collected in Table IX. The effects of a prolonged spring and summer drought, like that of 1893, are exemplified in the circumstance that four corn crops and the two hay crops all register their *minimum* average yields that year. On the other hand, the season of 1898 was exceptionally favourable to cereals and to hay. The effects of a prolonged autumn drought, as distinguished from spring and summer drought, are shown in the very low yield of turnips in 1899. Mangels are sown earlier and have a longer period of growth than turnips; if they become well established in the summer they are less susceptible to autumn drought. The hay made from clover, sainfoin, and grasses under rotation generally gives a bigger average yield than that from permanent grass land. The mean values at the foot of the table—they are not, strictly speaking, exact averages—indicate the average yields per acre in the United Kingdom to be about 30 bushels of wheat, 34 bushels of barley, 40 bushels of oats, 27 bushels of beans, 26 bushels of peas, 4½ tons of potatoes, 13 tons of turnips and swedes, 17 tons of mangels, 31 cwt. of hay from temporary grass, and 28 cwt. of hay from permanent grass. Although enormous single crops of mangels are sometimes grown, amounting occasionally to 100 tons per acre, the general average yield of 17 tons is about 4 tons more than that of turnips and swedes. Again, although from the richest old permanent meadow lands very heavy crops of hay are taken season after season, the general average yield of permanent grass is about 3 cwt. of hay per acre less than that from clover, sainfoin, and grasses under rotation. The general average yields of the corn crops are not fairly comparable one with the other because they are given by measure and not by weight, whereas the weight per bushel varies considerably. For purposes of comparison it would be much better if the yields of corn crops were estimated in cwt. per acre. This, indeed, is the practice in Ireland, and in order to incorporate the Irish figures with those for Great Britain so as to obtain average values for the United Kingdom, the Irish yields are calculated into bushels at the rate of 60 ℔ to the bushel of wheat, of beans, and of peas, 50 ℔ to the bushel of barley, and 39 ℔ to the bushel of oats.

Table IX.—*Estimated Annual Average Yield per Acre of Crops in the United Kingdom*, 1890-1900.

Year.	Wheat.	Barley.	Oats.	Beans.	Peas.	Potatoes.	Turnips.	Mangels.	Hay.	
									Rotation.	Permanent.
	Bush.	Bush.	Bush.	Bush.	Bush.	Tons.	Tons.	Tons.	Cwt.	Cwt.
1890	30·66	35·23	41·54	32·77	28·71	3·53	14·27	17·76	33·19	30·81
1891	31·30	34·72	40·46	29·82	28·23	4·74	13·40	18·60	31·39	28·13
1892	26·48	34·78	39·82	22·88	25·85	4·45	14·04	17·99	29·10	23·30
1893	26·08	29·30	38·14	19·61	22·61	5·28	13·66	13·26	23·56	20·41
1894	30·70	34·77	42·34	29·17	25·64	3·82	13·53	18·02	36·77	33·65
1895	26·33	32·09	38·67	22·98	22·62	5·64	13·11	16·44	29·08	25·21
1896	33·63	34·16	37·97	25·69	26·34	4·93	12·79	14·99	27·95	24·14
1897	29·07	32·91	38·34	28·91	27·65	3·47	13·90	18·08	32·53	30·71
1898	34·75	36·24	42·27	31·13	27·60	5·23	12·74	17·71	36·49	34·27
1899	32·76	34·64	40·57	30·19	27·22	4·82	9·97	17·41	31·04	29·11
Mean, 10 yrs.	30·18	33·88	40·06	27·26	26·14	4·59	13·14	17·02	31·01	27·97

The figure denoting the general average yield per acre of any class of crop needs readjusting after every successive harvest. If a decennial period be taken, then—for the purpose of the new calculation—the earliest year is omitted and the latest year added, the number of years continuing at ten. Adopting this course in the case of the cereal crops of Great Britain the decennial averages recorded in Table X. are obtained, the period 1885-94 being the earliest decade for which the official figures are available. It thus appears that the average yield of wheat in Great Britain, as calculated upon the crops harvested during the ten years of the 'nineties (1890-99), exceeded 30 bushels to the acre, whereas shortly before, as for the ten years ended 1895, it fell below 29 bushels. A large expansion in the acreage of the wheat crop would probably be attended by a decline in the average yield per acre, for when a crop is shrinking in area the tendency is to withdraw from it first the land least suited to its growth. The general average for the United Kingdom might then recede to rather less than 28 bushels of 60 ℔ per bushel, which was for a long time the accepted average—unless, of course, improved methods of cultivating and manuring the soil were to increase its general wheat-yielding capacity.[1]

Table X.—*Decennial Average Yields in Great Britain of Wheat, Barley, and Oats—Bushels per acre.*

10-Year Periods.	Wheat.	Barley.	Oats.
1885-1894	29·32	33·02	38·21
1886-1895	28·81	32·68	38·23
1887-1896	29·49	32·82	38·13
1888-1897	29·19	32·97	38·51
1889-1898	29·86	33·26	38·86
1890-1899	30·15	33·50	38·81

Live Stock.

The numbers of live stock in the United Kingdom are shown at five-yearly intervals in Table XI. Under horses are embraced only unbroken horses and horses used solely for agriculture (including mares kept for breeding). The highest and lowest annual totals for the United Kingdom in the period 1875-1900 were the following:—

Table XI.—*Numbers of Horses, Cattle, Sheep, and Pigs in the United Kingdom.*

Year.	Horses.	Cattle.	Sheep.	Pigs.
1875	1,819,687	10,162,787	33,491,948	3,495,167
1880	1,929,680	9,871,153	30,239,620	2,863,488
1885	1,909,200	10,868,760	30,086,200	3,686,628
1890	1,964,911	10,789,858	31,667,195	4,362,040
1895	2,112,207	10,753,314	29,774,853	4,238,870
1900	2,000,402	11,454,902	31 054,547	3,663,669

	Highest.	Lowest.	Difference.
Horses	2,112,207 in 1895	1,819,687 in 1875	292,520
Cattle	11,619,417 in 1892	9,731,537 in 1877	1,787,880
Sheep	33,642,808 in 1892	27,448,220 in 1882	6,194,588
Pigs	4,362,040 in 1890	2,863,488 in 1880	1,498,552

The highest total in each case is in the 'nineties. After the maximum year of 1892 cattle and sheep declined continuously for three years to the totals of 1895, the diminution being mainly the result of the memorable drought of 1893. Sheep, which numbered 32,571,018 in 1878, declined continuously to 27,448,220 in 1882—a loss of over five million head in five years. This was chiefly attributable to the ravages of the liver fluke which

---

[1] The higher yield of wheat in recent years appears to be largely attributable to better grain-growing seasons. The yields in the experimental wheat-field at Rothamsted—where there is no change either of land or of treatment—indicate this. The following figures show the average yields per acre of the selected plots at Rothamsted over six 8-yearly periods from 1852 to 1899, and afford evidence that the higher yield of the last sixteen years is due to the seasons:—

Average of—	Bushels (of 60 ℔) per acre.
8 years 1852-59	28[illegible]
8 ,, 1860-67	29[illegible]
8 ,, 1868-75	27[illegible]
8 ,, 1876-83	25[illegible]
8 ,, 1884-91	29[illegible]
8 ,, 1892-99	30
32 ,, 1852-83	27¾
16 ,, 1884-99	30
48 ,, 1852-99	28½

The average of the first thirty-two years is thus 27¾ bushels per acre, of the last sixteen years 30 bushels, and of the whole forty-eight years 28½ bushels.

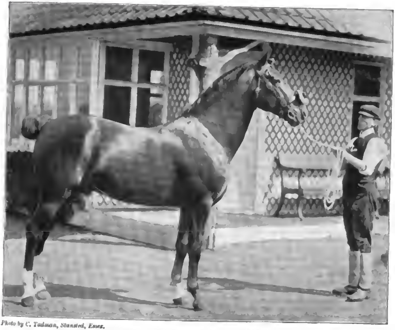


Photo by C. Tadman, Stansted, Essex.

HACKNEY STALLION, "ROYAL DANEGELT."

1st Prize and Champion, Royal Agricultural Society's Shows, Leicester, 1896; Manchester, 1897. 1st Prize and Challenge Cup, Hackney Horse Society's London Show, 1898, and 1st Prize, 1899 and 1900. The property of Sir Walter Gilbey, Bart., Elsenham Hall, Essex; bred by Mr. H. Livesey, Rotherfield, Sussex. (Height, 15·2 hands.)

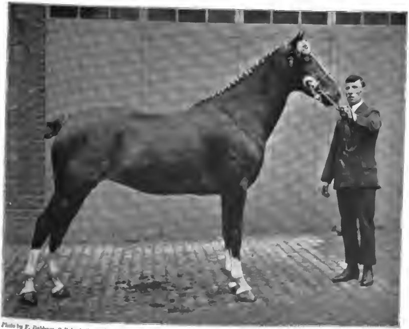


Photo by F. Babbage, 9 Robert Street, London, N.W.

HACKNEY MARE, "ROSADORA."

1st Prize, Royal Agricultural Society's Show, Maidstone, 1899. 1st Prize and Champion, Hackney Horse Society's London Shows, 1900 and 1901. The property of Mr. C. E. Galbraith, Terregles, Dumfries, N.B.; bred by Mr. J. F. Richardson, Norton Lodge, Malton, Yorkshire.

PLATE 2.

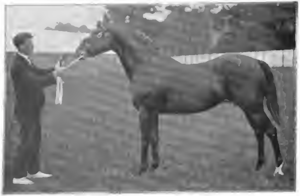


Photo by C. Reid, Wishaw, N.B.

Polo Pony Stallion, "Rosewater."

1st Prize and Champion, Royal Agricultural Society's Shows, Manchester, 1897; Birmingham, 1898; Maidstone, 1899; York, 1900; Cardiff, 1901. The property of Sir Walter Gilbey, Bart., Elsenham Hall, Essex; bred by Mr. A. W. Elphick, Preston Park, Brighton. Thoroughbred. (Height, 14·2 hands.)

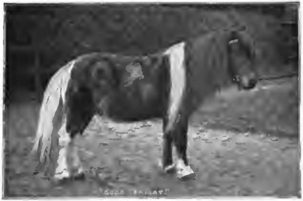


Photo by C. Reid, Wishaw, N.B.

Shetland Pony Stallion, "Good Friday."

1st Prize, Hackney Horse Society's London Shows, 1890, 1891, 1892, 1894, 1895, 1896. The property of Sir Walter Gilbey, Bart., Elsenham Hall, Essex: bred by the Marquis of Londonderry, K.G., Seaham Harbour, County Durham. (Height, 9 hands.)

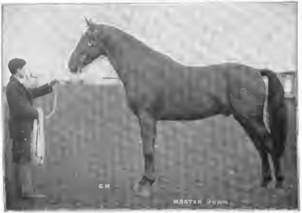
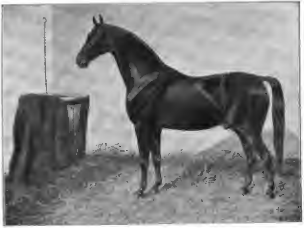


Photo by C. Reid, Wishaw, N.B.

Yorkshire Coach Horse, "Master John."

1st Prize and Champion, Royal Agricultural Society's Show, York, 1900. The property of, and bred by, Mr. John White, The Grange, Appleton Roebuck, Bolton Percy, Yorkshire.



Cleveland Bay Stallion, "Wellington."

1st Prize and Champion, Royal Agricultural Society's Show, York, 1900; 1st Prize, Maidstone, 1899. The property of, and bred by, Mr. H. C. Stephens, M.P., Cholderton, Salisbury.

began in the disastrously wet season of 1879. Pigs, being prolific breeders, fluctuate more widely in numbers than cattle or sheep, for the difference of 1,498,552 in their case represents fully one-third of the highest total, whereas the difference is less than one-seventh for horses, less than one-sixth for cattle, and less than one-fifth for sheep. The relative proportions—as distinguished from the actual numbers—in which stock are distributed over the several sections of the United Kingdom do not vary greatly from year to year. Table XII., in which the totals for the United Kingdom include those for the Channel Islands and Isle of Man, illustrates the preponderance of the sheep-breeding industry in the drier climate of Great Britain and of the cattle-breeding industry in the more humid atmosphere of Ireland. In Great Britain, for every head of cattle there are about four head of sheep, whereas in Ireland the cattle slightly outnumber the sheep. Again, whilst Great Britain possesses only half as many cattle more than Ireland, she possesses six times as many sheep. The cattle population of England alone slightly exceeds that of Ireland, but cattle are more at home on the broad plains of England than amongst the hills and mountains of Wales and Scotland, which afford suitable habitat for sheep. Hence it happens that, whilst in England sheep are not four times as numerous as cattle, in Wales they are nearly five times as numerous, and in Scotland more than six times as many. Great Britain has twice as many pigs as Ireland, but the swine industry is mainly English and Irish, and England is seen to possess nearly six times as many pigs as Wales and Scotland together, the number in the last-named country being particularly small. One English county alone, Suffolk, maintains more pigs than the whole of Scotland.

TABLE XII.—*Numbers of Horses, Cattle, Sheep, and Pigs in the United Kingdom in* 1900.

1900.	Horses.	Cattle.	Sheep.	Pigs.
England .	1,152,321	4,848,698	15,844,713	2,021,422
Wales .	153,284	758,386	3,432,516	228,097
Scotland .	194,538	1,198,086	7,814,997	132,413
Great Britain	1,500,143	6,805,170	26,592,226	2,381,932
Ireland .	491,143	4,608,443	4,386,697	1,268,474
United Kingdom[1]	2,000,402	11,454,902	31,054,547	3,663,669

IMPORTS OF LIVE ANIMALS AND MEAT.

The stock-breeders and graziers of the United Kingdom have, equally with the corn growers, to face the brunt of foreign competition, the aggregate importation, free of duty, of meat in the carcase and on the hoof continuing steadily to increase. Up to 1896 store cattle were admitted into the United Kingdom for the purpose of being fattened, but under the Diseases of Animals Act of that year animals imported since then have to be slaughtered at the place of landing. The dimensions of this trade are shown in Table XIII.

TABLE XIII.—*Numbers of Cattle, Sheep, and Pigs imported into the United Kingdom*, 1891-1900.

Year.	Cattle.	Sheep.	Pigs.
1891	507,407	344,504	542
1892	502,237	79,048	3826
1893	340,045	62,682	138
1894	475,440	484,597	8
1895	415,565	1,085,470	321
1896	562,553	789,592	4
1897	618,321	611,504	
1898	569,066	663,747	450
1899	503,504	607,755	
1900	495,645	382,833	

The animals come mainly from the United States of America, Canada, and Argentina, and the traffic in cattle is more uniform than that in sheep, whilst that in pigs seems to have reached extinction. The quantities of dead meat imported have increased with great rapidity, a circumstance largely due to the rise of the trade in chilled and frozen meat. Fresh beef in this form is imported chiefly from the United States and Australasia, fresh mutton from Australasia and Argentina.

Table XIV. shows how rapidly this trade expanded during the decade of the 'nineties. The column headed bacon and hams indicates clearly enough that the imports of fresh meat did not displace those of preserved pig meat, for the latter expanded from 4,715,000 cwt. to 7,784,000 cwt. during the decade. The column for all dead meat includes not only the items tabulated, but also the following, the quantities stated being those for 1900:—Beef, salted, 194,668 cwt.; beef, otherwise preserved, 516,529 cwt.; preserved mutton, 64,452 cwt.; salted pork, 248,710 cwt.; dead rabbits, 473,167 cwt.; meat, unenumerated, 754,114 cwt. The quantities of these are relatively small, and, excepting rabbits from Australia, they show no general tendency to increase. The extent to which these growing imports have been associated with a decline in value is shown in Table XV.

TABLE XIV.—*Quantities of Dead Meat imported into the United Kingdom*, 1891-1900—*Thousands of Cwt.*

Year.	Fresh Beef.	Fresh Mutton.	Fresh Pork.	Bacon and Hams.	All Dead Meat.
1891	1921	1663	128	4715	9,790
1892	2080	1700	132	5135	10,500
1893	1808	1971	182	4187	9,305
1894	2104	2295	180	4819	10,810
1895	2191	2611	288	5353	11,977
1896	2660	2895	299	6009	13,347
1897	3010	3193	348	8731	14,729
1898	3101	3314	558	7684	18,445
1899	3803	3446	669	7784	17,658
1900	4128	3393	695	7444	17,912

TABLE XV.—*Average Values of Fresh Meat, Bacon, and Hams imported into the United Kingdom*, 1891-1900 —*Per Cwt.*

Year.	Fresh Beef.		Fresh Mutton.		Fresh Pork.		Bacon.		Hams.	
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
1891	42	1	39	6	47	6	37	11	46	4
1892	42	5	40	6	46	11	40	10	47	4
1893	42	4	39	3	50	0	53	0	58	5
1894	40	0	37	10	48	5	43	10	49	1
1895	39	0	35	2	46	1	39	0	44	11
1896	37	10	32	7	45	11	34	8	43	0
1897	38	5	30	3	44	0	35	5	42	8
1898	38	2	29	7	41	10	36	2	39	6
1899	38	8	31	7	41	11	35	10	41	5
1900	39	7	34	5	43	0	41	9	48	10

The trend of the import trade in meat, live and dead, may be gathered from Table XVI., in which are given the annual average imports for the seven quinquennial periods embraced between 1866 and 1900. An increase in live cattle has accompanied a decrease in live sheep and pigs, but the imports of dead meat have expanded nearly fourteen-fold over the period.

The rate at which the trade in imported frozen mutton is increasing as compared with the industry in home-n mutton is illustrated in the figures published ally by Messrs W. Weddel & Company, from which for 1885 and for each year from 1890 to 1900 are

---

[1] Including Channel Islands and Isle of Man.

E XVI.—*Average Annual Imports of Cattle, Sheep, and Pigs, and of Dead Meat, into the United Kingdom over seven 5-yearly Periods.*

eriod.	Cattle.	Sheep.	Pigs.	Dead Meat.
	No.	No.	No.	Cwt.
36-70	194,947	610,800	64,827	1,155,867
71-75	215,990	864,516	74,040	3,134,175
76-80	272,745	938,704	44,613	5,841,913
81-85	387,282	974,316	24,355	6,012,495
86-90	438,098	800,599	19,437	7,681,729
91-95	448,139	407,260	967	10,436,549
96-1900	549,818	607,086	91	15,785,354

n in Table XVII. The home-grown is the *estimated* weight of sheep and lambs slaughtered, which is n at 40 per cent. of the total number of sheep and s returned each year in the United Kingdom. In the orted column is given the weight of fresh (frozen) mutton lamb imported, plus the *estimated* dead weight of the

LE XVII.—*Home Product and Imports of Sheep and Mutton into the United Kingdom—Thousands of Tons.*

Year.	Home-grown.	Imported.	Year.	Home-grown.	Imported.
1885	322	47	1895	319	157
1890	339	92	1896	329	164
1891	359	92	1897	327	175
1892	360	87	1898	333	182
1893	340	100	1899	339	187
1894	322	128	1900	332	179

ep imported on the hoof for slaughter. The home production of mutton would appear to have reached its limit, the quantity entered under this head for 1899 is seen be no more than that for 1890. On the other hand, the antity imported in 1899 is double that in 1890, and quadle that in 1885. Moreover, in 1885 the imported proct was only about one-seventh as much as the home-grown,

ABLE XVIII.—*Average Prices of Dead Meat per Stone of ℔ at the London Central Market in* 1898 *and in* 1899.

Description.	1898.	1899.
	s. d. s. d.	*s. d. s. d.*
BEEF.		
otch, short sides	3 11 to 4 3	4 3 to 4 6
,, long sides	3 8 ,, 3 10	3 11 ,, 4 1
glish	3 6 ,, 3 8	3 9 ,, 3 11
ws and Bulls	2 0 ,, 2 8	2 0 ,, 2 10
nerican, Birkenhead-killed	3 1 ,, 3 5	3 5 ,, 3 8
,, Deptford-killed	3 2 ,, 3 5	3 6 ,, 3 9
rgentine, Deptford-killed	2 7 ,, 2 11	3 0 ,, 3 4
nerican, refrigerd., hind-quarters	3 6 ,, 3 9	3 7 ,, 3 10
,, ,, fore-quarters	2 2 ,, 2 5	2 4 ,, 2 6
ustralian, frozen, hind-quarters	1 11 ,, 2 1	2 1 ,, 2 4
,, ,, fore-quarters	1 6 ,, 1 8	1 8 ,, 1 9
ew Zealand, ,, hind-quarters	2 2 ,, 2 4	2 3 ,, 2 6
,, ,, fore-quarters	1 8 ,, 1 10	1 9 ,, 1 11
MUTTON.		
cotch, prime	4 1 ,, 4 8	4 5 ,, 4 11
nglish, prime	3 10 ,, 4 5	4 2 ,, 4 8
wes	2 9 ,, 3 3	3 1 ,, 3 6
ontinental	3 7 ,, 3 11	3 9 ,, 4 2
iver Plate, town-killed	3 0 ,, 3 3	3 3 ,, 3 6
New Zealand, frozen	1 9 ,, 2 6	1 11 ,, 2 8
ustralian ,,	1 8 ,, 1 10	1 10 ,, 2 0
iver Plate ,,	1 8 ,, 1 9	1 11 ,, 2 0
LAMB.		
English	4 10 ,, 5 9	5 0 ,, 6 2
New Zealand, frozen	3 1 ,, 3 5	2 11 ,, 3 3

whereas in 1890 it was more than one-fourth, and in 1897 and each year since more than one-half. This large import trade in fresh meat, which sprang up entirely within the last quarter of the 19th century, has placed an abundance of cheap and wholesome food well within the reach of the great industrial populations of the United Kingdom. At the same time it cannot be gainsaid that it has opened the way to fraud, when butchers have palmed off upon their customers imported fresh meat as home-grown, and secured a dishonest profit by charging for it the prices of the latter, which are considerably in excess of those of the imported product. How wide is the margin for obtaining a fraudulent profit in this way is shown by the prices of home-grown and imported meat in Table XVIII. taken from the Agricultural Returns.

Many suggestions have been made to render it an offence at law for a seller to offer imported fresh meat as home-grown, but up to 1901 no legislative effect had been given to these proposals.

SALE OF CATTLE BY LIVE WEIGHT.

In connexion with the internal live stock trade of Great Britain attention must be directed to the Markets and Fairs (Weighing of Cattle) Act, 1891. The object of this measure is to replace the old-fashioned system of guessing at the weight of an animal by the sounder method of obtaining the exact weight by means of the weighbridge. The grazier buys and sells cattle much less frequently than the butcher buys them, so that the latter is naturally more skilled in estimating the weight of a beast through the use of the eye and the hand. The resort to the weighbridge should put both on an equality, but the method does not seem to have found much favour. Under the Act there are 15 scheduled places in England and 6 in Scotland, or 21 altogether (19 previous to 1898), from which returns are regularly obtained. The numbers of cattle weighed at these places in the seven years, 1893 to 1899, were respectively 92,492, 96,344, 100,033, 109,184, 111,767, 138,652, and 139,482, so that there was an increase of about 50 per cent. during the period. The numbers for Scotland are greater throughout than those for England. The scheduled places at which weighing appears to be most resorted to are Edinburgh, Aberdeen, and Glasgow in Scotland, and London, Shrewsbury, Carlisle, and Liverpool in England. But, as will be apparent from Table XIX., the number of cattle weighed bears but an insignificant proportion to the total which pass through the scheduled markets. The figures given in Table XX. for the two years, 1898 and 1899, show how little use is made of the weighbridge in the sale of sheep and swine. Now that weighbridges are moderate in price and excellent in quality they are placed in most markets, so that there is little excuse for retaining the old empirical method of sale. As the primary object of the Act is to obtain records of prices realized, together with the description of the animals involved, are obtained is the full advantage of the statute secured. In 1899 average prices for cattle of first or prime quality ranged from 32s. 2d. per cwt. in Leeds to 38s. per cwt. in London. For second quality beasts

TABLE XIX.—*Nos. of Cattle Weighed in Great Britain under the Markets and Fairs Weighing of Cattle Act,* 1893-1900.

Year.	Entering Markets.	Weighed.	Weighed.
	No.	No.	Per Cent.
1893	1,219,208	92,492	7·59
1894	1,203,533	96,344	8·01
1895	1,186,149	100,033	8·43
1896	1,000,014	109,184	9·93
1897	1,115,183	111,767	10·02
1898	1,263,991	138,652	10·97
1899	1,236,091	139,482	11·28
1900	1,187,603	141,611	11·92

PLATE 2.

PLATE 3.

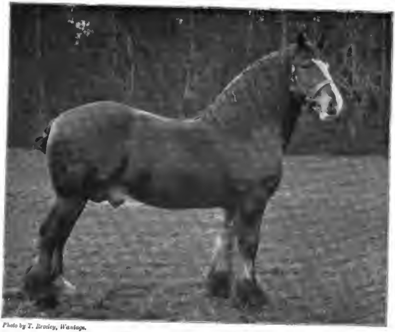


Photo by T. Reveley, Wantage.

SHIRE STALLION, "BUSCOT HAROLD."

1st Prize and Champion, London Shire Horse Shows, 1898, 1899, 1900. The property of, and bred by, Mr. Alexander Henderson, M.P., Buscot Park, Faringdon, Berks.

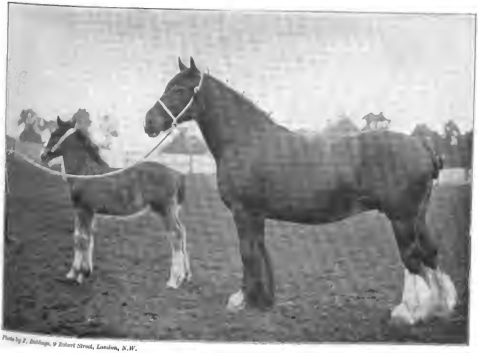


Photo by F. Babbage, 9 Robert Street, London, N.W.

SHIRE MARE, "STANNEY COMMOTION."

1st Prize, Royal Agricultural Society's Show, York, 1900. The property of Sir J. Blundell Maple, Bart., M.P., Childwick, St. Albans; bred by Mr. William Parker, Great Stanney Hall, Sutton, Chester.

PLATE 4.

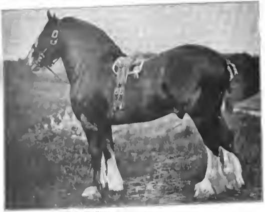


Photo by R. Gilchrist, Netherhall.

CLYDESDALE STALLION, "BARON'S PRIDE."

1st Prize and Champion, Highland and Agricultural Society's Show, Aberdeen, 1894. The property of Messrs. W. and A. Montgomery, Netherhall and Banks, Kirkcudbright; bred by Messrs. R. and J. Findlay, Springhill, Baillieston.

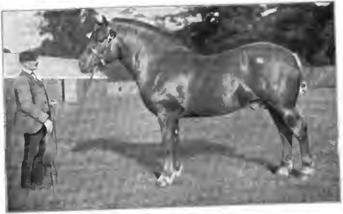


Photo by C. Reid, Wishaw, N.B.

SUFFOLK STALLION, "SATURN."

1st Prize, Royal Agricultural Society's Show, Maidstone, 1899. The property of, and bred by, Mr. Alfred J. Smith, Rendlesham, Woodbridge, Suffolk.

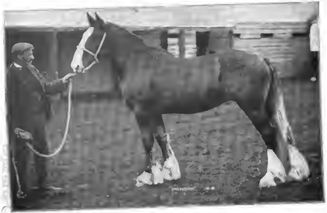


Photo by A. Brown and Co., Lanark.

CLYDESDALE FILLY, "POMONA."

1st Prize and Champion Female at Edinburgh Agricultural Society's Show, 1900, as a yearling. The property of the Earl of Rosebery, K.G., Dalmeny Park, Edinburgh; bred by Her Majesty Queen Victoria, The Prince Consort's Shaw Farm, Windsor.

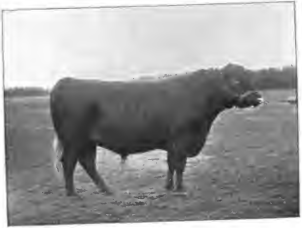


Photo by R. H. Lord, Cambridge.

RED POLLED BULL, "FIELD RANGER."

1st Prize, Norfolk Agricultural Society's Show, 1900. The property of, and bred by, His Royal Highness the Duke of Cornwall and York, K.G., Sandringham.

the range was from 28s. 10d. per cwt. in Leeds to 34s. 6d. in Edinburgh. In the case of third quality cattle the lowest average was 24s. 6d. per cwt. in Liverpool, and the highest was 31s. 8d. in Glasgow. These examples illustrate the kind of information which the Act is competent to elicit. The number of fat cattle which were reported as having been actually sold by live weight at an agreed-on price per cwt. or per stone—a most commendable innovation—was greater than ever before in 1899, and amounted to 16,844 head. The weighing of store cattle for sale is, like that of fat cattle, slowly extending.

TABLE XX.—*Nos. of Animals Weighed in* 1898-99 *under the Markets and Fairs (Weighing of Cattle) Act.*

	1898.	1899.
	No.	No.
Cattle:—		
Entering markets . . .	1,263,991	1,236,091
Weighed	138,652	139,482
Prices returned with quality distinguished	102,299	103,613
Sheep:—		
Entering markets . . .	4,691,619	4,681,602
Weighed	49,953	48,643
Prices returned with quality distinguished	40,460	42,154
Swine:—		
Entering markets . . .	363,370	455,056
Weighed	1,614	2,205
Prices returned with quality distinguished	1,437	2,070

EARLY MATURITY.

Smithfield shows.

In the fattening of animals for the butcher the principle of early maturity has received full recognition. If the sole purpose for which an animal is reared is to prepare it for the block—and this is the case with steers amongst cattle and with wethers amongst sheep—the sooner it is ready for slaughter the less should be the outlay involved. During the whole time the animal is living the feeder has to pay what has been termed the "life tax"—that is, so much of the food has to go to the maintenance of the animal as a living organism, independently of that which may be undergoing conversion into what will subsequently be available in the form of beef or mutton. If a bullock can be rendered fit for the butcher at the age of two or three years, will the animal repay another year's feeding? It has been proved at the Christmas fat stock shows that the older a bullock gets the less will he gain in weight per day as a result of the feeding. With regard to this point the work of the Smithfield Club deserves recognition. This body was instituted in 1798 as the Smithfield Cattle and Sheep Society, the title being changed to that of the Smithfield Club in 1802. The original object—the supply of the cattle markets of Smithfield and other places with the cheapest and best meat—is still kept strictly in view. The judges, in making their awards at the show held annually in December, at (since 1862) Islington, North London, are instructed to decide according to quality of flesh, lightness of offal, age, and early maturity, with no restrictions as to feeding, and thus to promote the primary aim of the club in encouraging the selection and breeding of the best and most useful animals for the production of meat, and testing their capabilities in respect of early maturity. At the first show held (at Smithfield) in 1799, two classes were provided for cattle and two for sheep, the prizes offered amounting to £52:10s. In 1839 the classes comprised seven for cattle, six for sheep, and one for pigs, with prizes to the amount of £300. By 1862 the classes had risen to 29 for cattle, 17 for sheep, and 4 for pigs, and the prize money to £2072. At the centenary show in 1898 provision was made for 40 classes for cattle, 29 for sheep, 18 for pigs, and 7 for animals to be slaughtered, whilst to mark the importance of the occasion the prizes offered amounted to close upon £5000 in value. In 1900 there were 36 classes for cattle, 32 for sheep, 18 for pigs, and 7 for cattle and sheep to be slaughtered, and the value of the prizes was £3894. The sections provided for cattle are properly restricted to what may be termed the beef breeds; in the catalogue order they are Devon, Hereford, Shorthorn, Sussex, Red Polled, Aberdeen-Angus, Galloway, Welsh, Highland, cross-bred, and a section for Kerry, Dexter, and Shetland. It will be noticed that such characteristically milking breeds as the Ayrshire, Jersey, and Guernsey have no place here. Provision is made, however, for all the well-known breeds of sheep and swine. In the cattle classes, aged beasts of huge size and of considerably over a ton in weight used to be common, but in recent years the tendency has been to reduce the upper limit of age, and thus to bring out animals ripe for the butcher in a shorter time than was formerly the case. The latest important step in this direction was taken in 1896, when the senior class for steers, viz., animals three to four years old, was abolished, the *maximum* age at which steers were allowed to compete for prizes being reduced to three years. The cow classes were abolished in 1897, and in the schedule of the 1900 exhibition the classes for each breed of cattle were (1) for steers not exceeding two years old, (2) for steers above two years and not exceeding three years old, and (3) for heifers not exceeding three years old. The single exception is provided by the slowly-maturing Highland breed of cattle, for which classes were allotted to (1) steers not exceeding three years old, (2) steers or oxen above three years old (with no *maximum* limit), and (3) heifers not exceeding four years old. As illustrating heavy weights, there were in the 1893 show, out of 310 entries of cattle, four beasts which weighed over a ton. They were all steers of three to four years old, one being a Hereford weighing 20 cwt. 2 qr. 4 ℔, and the others Shorthorns weighing respectively, 20 cwt. 2 qr., 20 cwt. 3 qr. 21 ℔, and 22 cwt. 2 qr. 18 ℔. In the 1895 show, out of 356 entries of cattle, there were seven beasts of more than a ton in weight. They were all three to four years old, and comprised four Shorthorns (top weight 21 cwt. 1 qr. 18 ℔), one Sussex (22 cwt. 3 qr. 7 ℔), and two cross-breds (top weight 20 cwt. 3 qr. 24 ℔). In the 1899 show, with 311 entries of cattle, and the age limited to three years, no beast reached the weight of a ton, the heaviest animal being a cross-bred (Aberdeen-Angus and Shorthorn) which, at three years old, turned the scale at 19 cwt. 1 qr. 5 ℔. Out of 259 entries of cattle at the show of 1900 the top weight was 19 cwt. 2 qr. 3 ℔ in the case of a Red Polled steer, aged two years eleven months, the next being 18 cwt. 2 qr. 6 ℔ for a Hereford steer two years eight and a half months old. Useful figures for purposes of comparison are obtained by dividing the weight of a fat beast by the number of days in its age, the weight at birth being thrown in. The average daily gain in live weight is thus arrived at, and as the animal increases in age this average gradually diminishes, until the daily gain reaches a stage at which it does not afford any profitable return upon the food consumed. At the centenary show of the Smithfield Club in 1898 the highest average daily gains in weight amongst prize-winning cattle were provided by a Shorthorn-Aberdeen cross-bred steer (age, one year seven months; daily gain 2·47 ℔); a Shorthorn steer (age, one year seven months; daily gain, 2·44 ℔); and an Aberdeen-Shorthorn cross-bred steer (age, one year ten months; daily gain, 2·33 ℔). These beasts, it will be observed, were all under two years old. Amongst prize steers of two and a half to three years old, on the same occasion, the three highest daily average gains in live weight were 2·07 ℔ for an Aberdeen-Angus, 1·99 ℔ for a Shorthorn-Aberdeen cross-bred, and 1·97 for a Sussex. In the sheep section of the Smithfield show the classes for ewes were finally abolished in 1898, and the classes restricted to wethers and wether lambs, whose function is exclusively the production of meat. At the 1900 show sheep of each breed, and also cross-breds, competed as (1) wether lambs under twelve months old, and (2) wether sheep above twelve and under 24 months old. The only exception was in the case of the slowly-maturing Cheviot and mountain breeds, for which the second class was for wether sheep of any age above twelve months. Of prize sheep at the centenary show the largest average daily gain was 0·77 ℔ per head given by Oxford-Hampshire cross-bred wether lambs, aged nine months two weeks. In the case of wether sheep, twelve to twenty-four months old, the highest daily increase was 0·56 ℔ per head as yielded by Lincolns, aged twenty-one months. Within the last quarter of the 19th century the stock-feeding practices of the country were much modified in accordance with these ideas of early maturity. The three-year old wethers and older oxen that used to be common in the fat stock markets are now rarely seen, excepting perhaps in the case of mountain breeds of sheep and Highland cattle. It was in 1875 that the Smithfield Club first provided competitive classes for lambs, and in 1883 the champion plate offered for the best pen of sheep of any age in the show was for the first time won by lambs, a pen of Hampshire Downs. The young classes for bullocks were established in 1880. The time-honoured notion that an animal must have completed its growth before it could be profitably fattened is no longer held, and the improved breeds which now exist rival one another as regards the early period at which they may be made ready for the butcher, by appropriate feeding and management.

In 1895 the Smithfield Club instituted a carcase competition in association with its annual show of fat stock, and it has been continued each year since. The cattle and sheep entered for this competition are shown alive on the first day, at the close of which they are slaughtered and the carcases hung up for exhibition, with details of live and dead weights. The competition thus constitutes what is termed a "block test," and it is instructive in affording the opportunity of seeing the quality of the carcases furnished by the several animals, and in particular the relative proportion and distribution of fat and lean meat. The live animals are judged and subsequently the carcases, and, though the results sometimes agree, more often they do not. Tables are constructed showing the fasted live weight, the carcase weight, and the weight of the various parts that are separated from and not included with the carcase. An abundance of lean meat and a moderate amount of fat well distributed constitutes a better carcase, and a more economical one for the consumer, than a carcase in which gross accumulations of fat are prominent. To add to the educational value of the display, information as to the methods of feeding would be desirable, as it would then be possible to correlate the quality of the meat with the mode of its manufacture. A point of high practical interest is the ratio of carcase weight to fasted live weight, and in the case of prize-winning carcases these ratios usually fluctuate within very narrow limits. At the 1899 show, for example, the highest proportion of carcase weight to live weight was 68 per cent. in the case of an Aberdeen-Angus steer and of a Cheviot wether, whilst the lowest was 61 per cent., afforded alike by a Shorthorn-Sussex cross-bred heifer and a Mountain lamb. A familiar practical method of estimating carcase weight from live weight is to reckon one Smithfield stone (8 ℔) of carcase for each imperial stone (14 ℔) of live weight. This gives carcase weight as equal to 57 per cent. of live weight, a ratio much inferior to the best results obtained at the carcase competition promoted by the Smithfield Club. Table XXI., given as an example, relates to prize carcases in the competition at the 1900 show.

TABLE XXI.—*Block Test, Smithfield Club Show*, 1900.

Prize.	Description and Breed.	Fasted Live Weight.	Carcase Weight.	Ratio of Carcase to Live Weight.
		℔	℔	Per cent.
	CATTLE.			
	Steers, not over two years old:—			
1	Aberdeen-Hereford	1192	787	66
2	Shorthorn-Galloway	1297	843	65
3	Aberdeen-Shorthorn	1315	847	64
	Steers, two to three years old:—			
1	Aberdeen-Angus	1332	878	66
2	Aberdeen-Shorthorn	1361	927	67
3	Shorthorn-Galloway	1418	897	63
	Heifers, not over three years old:—			
1	Aberdeen-Angus	1304	817	63
3	Aberdeen-Sussex	1290	801	62
	SHEEP.			
	Longwool Lambs, not over 12 months old:—			
1	Devon cross	141	85	60
2	Suffolk cross	118	71	60
3	Cheviot	123	77	63
	Longwool Wethers, 12 to 24 months old:—			
1	Mountain	165	105	64
2	Suffolk-Cheviot	158	99	63
3	Cheviot	147	91	62
	Shortwool Lambs, not over 12 months old:—			
1	Southdown-Suffolk	120	81	67½
2	Hampshire Down	138	87	63
3	Hampshire Down	150	95	63
	Shortwool Wethers, 12 to 24 months old:—			
1	Norfolk-Horned	160	106	66
2	Hampshire Down	172	103	60
3	Southdown	109	68	62

THE BREEDS OF LIVE STOCK.

In the last quarter of the 19th century the many native breeds of farm live stock became more clearly defined than ever before, and various breeds which at the beginning of that period had received no separate classification in show-yard schedules were fully recognised before its close. As a matter of record, it is deemed desirable to notice the breeds as they stand at the beginning of the 20th century. For fuller details than it is here possible to give, the reader should consult the respective stud books, herd books, and flock books pertaining to the several breeds.

Horses.

The breeds of *light* horses include the Thoroughbred, the Yorkshire Coach-horse, the Cleveland Bay, the Hackney, and the pony; of *heavy* horses, the Shire, the Clydesdale, and the Suffolk. The *Thoroughbred* is the oldest of the breeds, and it is known as the "blood-horse" on account of the length of time through which its purity of descent can be traced. It has sprung from the old native horses of England. In past times Arab and Turkish sires were imported for the improvement of the breed, though the use of Eastern blood has, with a few

PLATE 5.

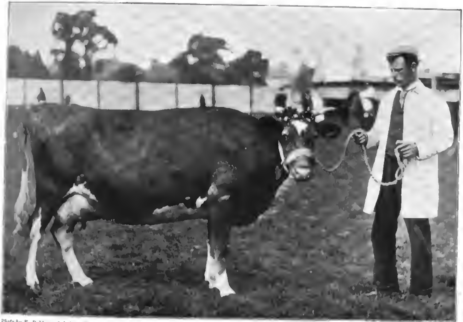


Photo by F. Babbage, 9 Robert Street, London, N.W.

GUERNSEY COW, "JESSIE 10TH."

1st Prize, Royal Agricultural Society's Show, York, 1900. The property of, and bred by, the Hon. Mrs. A. Baillie-Hamilton,
Burley Lodge, Ringwood, Hants.

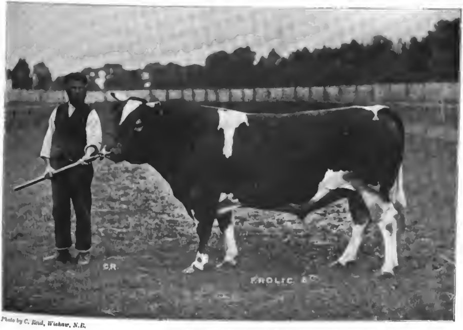


Photo by C. Reid, Wishaw, N.B.

GUERNSEY BULL, "FROLIC 6TH."

1st Prize, Royal Agricultural Society's Shows, Maidstone, 1899; York, 1900. The property of, and bred by, Mr. W. A. Glynn,
Seagrove, Seaview, Isle of Wight.

PLATE 6.

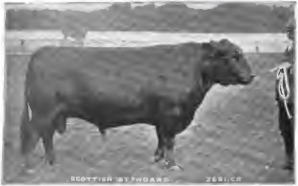


Photo by C. Reid, Wishaw, N.B.

GALLOWAY BULL, "SCOTTISH STANDARD."

1st Prize, Royal Agricultural Society's Show, Maidstone, 1899. The property of Mr. John Cunningham, Durham Hill, Dalbeattie; bred by Mr. C. Graham, Harelaw Hill, Canonbie.

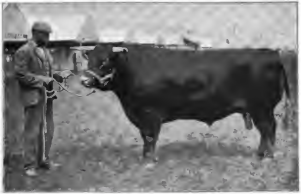


Photo by C. Reid, Wishaw, N.B.

SUSSEX BULL, "ALFRED."

1st Prize, Royal Agricultural Society's Shows, Maidstone, 1899; York, 1900. The property of Mr. Philip Saillard, Burhan Hill, Crawley, Sussex; bred by Mr. J. H. T. Broadwood, Lyne, Horsham.

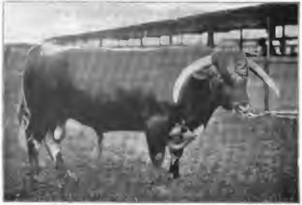


Photo by F. Babbage, 9 Robert Street, London, N.W.

LONGHORN BULL, "WOOTTON WONDER."

1st Prize, Royal Agricultural Society's Shows, York, 1900; Cardiff, 1901. The property of, and bred by, Mr. H. Jasper Selwyn, Leek Wootton, Warwick.

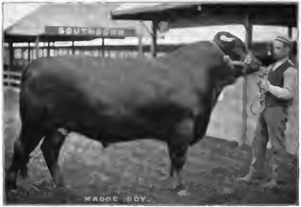


Photo by C. Reid, Wishaw, N.B.

WELSH BULL, "MADOC BOY."

1st Prize, Royal Agricultural Society's Shows, Birmingham, 1898; York, 1900. The property of, and bred by, Mr. R. M. Greaves, Wern, Portmadoc, Carnarvonshire.

exceptions, long since been abandoned. The frame of the thoroughbred is light, slender, and graceful; its limbs are clean cut and sinewy, its skin is fine, its hair is glossy, and its eyes are bright and intelligent. Being so highly bred it is apt to be nervous and excitable, and is sometimes unruly, but its speed, resolution, and endurance, as tested on the racecourse, are beyond praise. The demand for *hunting horses* has, during recent years, been productive of useful efforts to improve their quality by crossing thoroughbred stallions with half-bred mares, and work of this nature has been readily undertaken on many horse-breeding farms, stimulated by the premiums offered by the Royal Commission on Horse-breeding. A good type of *hunter horse* should be thick and strong on the back and loin, with long, powerful quarters and muscular thighs, and hocks neatly shaped and clean. The head should be long, lean, and blood-like, and the eye full. A mahogany-brown colour is in high favour, then black, bay, or dark chestnut. Greys, roans, and light chestnuts are less popular.

The *Yorkshire Coach-horse* is extensively bred in the North and East Ridings of York, and the thoroughbred has taken a share in its development. The colour is usually bay or brown, the legs being black. The mane and tail are abundant, but not curly. A fine head, sloping shoulders, strong loins, lengthy quarters, high-stepping action, flat legs, and sound feet are characteristic. The height varies from 16 hands to 16 hands 2 inches. The *Cleveland Bay* is a near relation of the Yorkshire coach-horse, and is bred in various parts of Yorkshire, Durham, and Northumberland. He is adapted alike for the plough, for heavy draught, and for slow saddle work. Some specimens make imposing-looking carriage horses. The colour is light or dark bay, with clean black legs, and black mane and tail. Though rather coarse-headed, the Cleveland Bay has a well-set shoulder and neck, a deep chest, and round barrel. The height is from 16 to 17 hands.

The *Hackney* has come prominently to the front in recent years. The term *Nag*, applied to the active riding or trotting horse, is derived from the Anglo-Saxon *knegan*, to neigh. The Normans brought with them their own word *haquenée*, or *hacquenée*, the French derivative from the Latin *equus*, a horse, whence the name hackney. Both nag and hackney continue to be used as synonymous terms. Frequent mention is made of hackneys and trotters in old farm accounts of the 14th century. The first noteworthy trotting hackney stallion, of the modern type, was a horse foaled about 1755, and variously known as the Schales horse, Shields, or Shales, and most of the recognized hackneys of to-day trace back to him. The breeding of hackneys is extensively pursued in the counties of Norfolk, Cambridge, Huntingdon, Lincoln, and York, and in the showyard competitions a keen but friendly rivalry is usually to be noticed between the hackney-breeding farmers of Norfolk and Yorkshire. Hackneys include both riding horses and driving horses. The aim of the breeder is to produce an animal which is saleable at an early age, which can be bred and reared at moderate expense, and which can be broken in without much risk. Excellent results have followed the use of hackney sires upon half-bred mares, the latter being the offspring of thoroughbred stallions and trotting mares. As regards the movement, or, as it is termed, the "action" of the hackney, he should go light in hand, and the knee should be so elevated and advanced during the trot as to be seen by the rider projecting beyond the breast, whilst, before the foot is put down, the leg should be well extended. Above all, the hackney should possess good hock action, as distinguished from mere fetlock action, the propelling power depending upon the efficiency of the former. To be classed as a hackney an animal must be over 14 hands high, that is, exceeding 56 inches.

The *Pony* differs essentially from the hackney in the matter of height, the former being required not to exceed 14 hands. There is, however, one exception, the nature of which is made clear in the following extract from Sir Walter Gilbey's *Ponies Past and Present*, 1900:—

> Before the establishment of the Hackney Horse Society in 1883 the dividing line between the horse and the pony in England was vague and undefined. It was then found necessary to distinguish clearly between horses and ponies, and, accordingly, all animals measuring 14 hands or under were designated "ponies," and registered in a separate part of the (Hackney) Stud Book. This record of height, with other particulars as to breeding, &c., serves to direct breeders in their choice of sires and dams. The standard of height established by the Hackney Horse Society was accepted and officially recognized by the Royal Agricultural Society in 1889, when the prize-list for the Windsor show contained pony classes for animals not exceeding 14 hands. The altered polo-rule, which fixes the limit of height at 14 hands 2 inches, may be productive of some little confusion; but for all other purposes 14 hands is the recognized *maximum* height of a pony. Prior to 1883 small horses were called indifferently Galloways, hobbies, cobs, or ponies, irrespective of their height.

Native ponies include those variously known as English, New Forest, Exmoor, Dartmoor, Cumberland and Westmorland, Highland, Shetland, and Connemara, the last-named comprising—according to Professor J. C. Ewart—five types, viz., Andalusian, Eastern, Cashel, Clydesdale, and Clifden. Ponies range in height from 14 hands down to 8½ or 9 hands, many Shetland ponies not exceeding the latter. As in the case of the hackney, so with the pony, thoroughbred blood has been used, and with good results. One object of the pony breeder is to control size,—to compress the most valuable qualities into the least compass. He endeavours to breed an animal possessing a small head, perfect shoulders, true action, and good manners. A combination of the best points of the hunter with the style and finish of the hackney produces a class of weight-carrying pony which is always saleable.

The *Shire* horse owes its happily-chosen name—of quite recent application, however,—to Arthur Young's remarks, in the description of his agricultural tours during the closing years of the 18th century, concerning the large black old English horse, "the produce principally of the *Shire* counties in the heart of England." Long previous to this, however, the word Shire, in connexion with horses, was used in the statutes of Henry VIII. By the various names of the War Horse, the Great Horse, the Old English Black Horse, and the Shire Horse, the breed has for centuries been cultivated in the rich fen-lands of Lincolnshire and Cambridgeshire, and in many counties to the west. The Shire is the largest of draught horses, the stallion commonly attaining a height of 17 to 17.3 hands. Though the black colour is still frequently met with, bay and brown are more usually seen. The lighter colours, such as chestnut, roan, and grey, are not so much in favour. With their immense size and weight—1800 ℔ to 2200 ℔—the Shires combine great strength, and they are withal docile and intelligent. They stand on short stout legs, with a plentiful covering—sometimes, perhaps, too abundant—of long hair extending down the back of the limbs from knees and hocks to pasterns. The head is of medium size, and broad between the eyes. The neck is fairly long, and well arched on to the shoulders, which are deep and strong, and moderately oblique. The chest is wide and full, the back short and straight, the ribs are round and deep, the hind quarters long, level, and well let down into the muscular thighs. The cannon-bones should be flat, heavy, and clean, and the feet wide, tough, and prominent at the heels. A good type of Shire horse combines symmetrical outlines and bold free action, with clean, heavy, flat bone, and soft silky hair. Despite the introduction of the motor-car there is a good and remunerative demand for Shire geldings for use as draught horses in towns.

The *Clydesdale*, the Scottish breed of which the native home is in the valley of the Clyde, is not quite so large as the Shire, the average height of stallions being about 16 hands 2 inches. The shoulder is more oblique than in the Shire. The popular colour is bay, particularly if of a dark shade, or dappled. Black is also a common colour, but grey is not encouraged. White markings on one or more of the legs, with a white star or stripe on the face, are quite usual. The "feathering," that is, the development of silky hair on the backs of the legs, as in the Shires, is a point to which Clydesdale breeders attach much importance, it being regarded as an indication of strong, healthy bone. The bones of the legs should be short, flat, clean, and hard. With symmetry, activity, strength, and endurance, the Clydesdale associates a good temper and willing disposition, is easily broken to harness, and makes an admirable draught horse.

The *Suffolk* is a horse quite distinct from the Shire and the Clydesdale, two breeds which possess many points in common. It stands altogether lower, its body looking almost too heavy for its limbs; it possesses a characteristic chestnut or light dun colour, and its legs are free from the "feather" which is so much admired in the two other heavy breeds. How long the Suffolks have been associated with the county after which they are named is unknown, but they are mentioned as long ago as 1586 in Camden's *Britannia*. With an average height of about 16 hands, they often have a weight of as much as 2000 lb, and this may explain the appearance which has given rise to the name of the Suffolk Punch, by which the breed is known. If the Suffolk is not in all respects a handsome animal, he is none the less a resolute and unwearying worker, and is richly endowed with many of the best qualities of a horse.

Cattle.

The recognized breeds of cattle in the British Isles comprise the Shorthorn, Hereford, Devon, South Devon or South Hams, Sussex, Welsh, Longhorn, Red Polled, Aberdeen-Angus, Galloway, Highland, Ayrshire, Jersey, Guernsey, Kerry, and Dexter. These names — with the four exceptions of Shorthorn, Longhorn, Red Polled, and Dexter — are geographical, and serve to indicate the "homes" of the several breeds or the places whence they originated. The Shorthorn, Hereford, Devon, South Devon, Sussex, Longhorn, and Red Polled breeds are native to England; the Aberdeen-Angus, Galloway, Highland, and Ayrshire breeds to Scotland; and the Kerry and Dexter breeds to Ireland. The Jersey and Guernsey breeds—often spoken of as Channel Islands cattle—belong to the respective islands whose names they bear, and great care is taken to keep Jersey cattle out of Guernsey, and Guernsey cattle out of Jersey. The term Alderney is obsolete, and no pure breed is designated by that name.

The *Shorthorn* is the most widely distributed of all the breeds of cattle, both at home and abroad. No census of breeds[1] has ever been taken in the United Kingdom, but such an enumeration would show the Shorthorn far to exceed in numbers any other breed, whilst the great majority of cross-bred cattle contain Shorthorn blood. During the last quarter of the 18th century the brothers Charles Colling (1751-1836) and Robert Colling (1749-1820) set to work, by careful selection and breeding, to improve the cattle of the Teeswater district in the county of Durham. If the Shorthorn did not actually originate thus, it is indisputable that the efforts of the Collings[2] had a profound influence upon the fortunes of the breed. It is still termed the Durham breed in most parts of the world except the land of its birth, and the geographical name is far preferable, for the term "shorthorn" describes no characteristic which is not shared by a number of other breeds. Other skilled breeders turned their attention to the Shorthorns and established famous strains, the descendants of which can be traced down to the present day. By Thomas Booth, who dwelt at Killerby and Warlaby in Yorkshire, the "Booth" strains of Shorthorns were originated. Similarly, by Thomas Bates, of Kirklevington in Yorkshire, the "Bates" families were established.[3] When Shorthorn breeders of to-day talk of "Booth blood," or of "Bates blood," they refer to animals descended from the respective herds of Thomas Booth and Thomas Bates.

Shorthorns are sometimes spoken of as the ubiquitous breed, and also as the "red, white, and roan" breed. The roan colour is very popular, and the full red has its supporters, as in the case of the Lincolnshire Red Shorthorns; unbroken white is not much in favour. The striking characteristic of the Shorthorn is the ease with which it adapts itself to varying conditions of soil, climate, and management. Add to this that the breed is equally noted both for its beef-making and its milk-yielding properties, and—serving as it thus does the dual purpose—it is not difficult to see why the Shorthorn is so extensively bred over such wide areas. Its importance exceeds that of any other breed, whether it be viewed as a grazier's beast or a dairyman's cow. Shorthorns may be seen at nearly all the fairs and cattle markets of Great Britain and Ireland, a statement that can be made of no other breed. For crossing purposes, for the production of beef-cattle, the Shorthorn is unrivalled.

The culmination of what may be termed the Booth and Bates period was in the year 1875, when the sales took place of Lord Dunmore's and Mr William Torr's herds, which realized extraordinary prices. In that black year of farming, 1879, prices were declining, and continued to do so till within the last few years of the close of the 19th century, when there set in a gradual revival, stimulated largely by the commercial prosperity of the country. The result of extremely high prices when line-bred animals were in fashion was a tendency to breed from all kinds of animals that were of the same tribe, without selection. Consequently, a deterioration set in, which was aggravated by the overlooking of the milking properties. Shorthorn breeders thus came to see that a change of blood was necessary. Meanwhile, for many years breeders in Aberdeenshire had been holding annual sales of young bulls and heifers from their herds. The late Mr Amos Cruickshank began his annual sales in the 'forties, and the late Mr W. T. Talbot-Crosbie had annual sales from his Shorthorn herd in the south-west of Ireland for a number of years. Many Aberdeen farmers emigrated to Canada, and bought Shorthorn calves in their native county to take with them. The Cruickshanks held their bull sales at that time, and numerous animals were bought by the small breeders in Canada. This continued until 1875, when the Cruickshanks had so much private demand that they discontinued their public sales. Subsequently, when Messrs Cruickshank sold their herd privately to Messrs Nelson for exportation the animals could not all be shipped, and

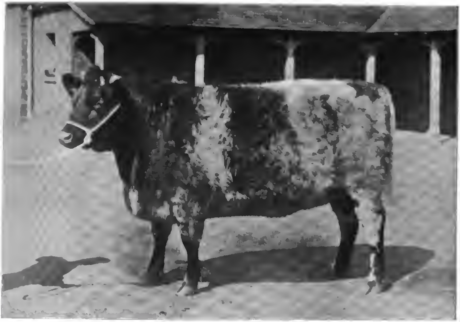
---

[1] In 1900 the bulls of Ireland were for the first time enumerated. There were 8406 Shorthorns, 764 Aberdeen-Angus, 376 Kerries, 329 Herefords, 116 Red Polled, 103 Dexters, 66 Channel Islands, and 4126 others and cross-breds; total, 14,286.

[2] C. J. Bates, "The Brothers Colling," *Jour. Roy. Agric. Soc.* 1899.

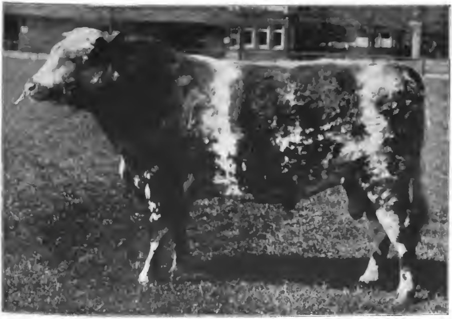
[3] C. J. Bates, *Thomas Bates and the Kirklevington Shorthorns: a Contribution to the History of Pure Durham Cattle.* Newcastle-upon-Tyne, 1897.

PLATE 7.



SHORTHORN COW, "CICELY."

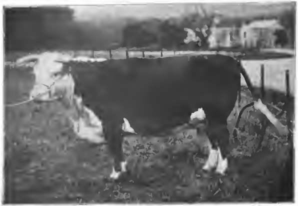
In 1899, 1st Prize, Royal Counties Agricultural Society's Show, Windsor; 1st Prize and Champion, Royal Agricultural Society's Show, Maidstone; 1st Prize and Champion, Highland and Agricultural Society's Show, Edinburgh. In 1900, 1st Prize and Champion, Royal Counties Agricultural Society's Show, Winchester; 1st Prize and Champion, Birmingham Cattle Show; 1st Prize and Shorthorn Champion, Smithfield Club Show. The property of, and bred by, Her Majesty Queen Victoria, the Prince Consort's Shaw Farm, Windsor.



SHORTHORN BULL, "ROYAL DUKE."

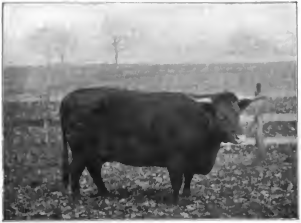
In 1899, 1st Prize, Highland and Agricultural Society's Show, Edinburgh. In 1900, 1st Prize and Champion, Royal Dublin Society's Show, Royal Counties Agricultural Society's Show at Winchester, Royal Agricultural Society's Show at York, and Highland and Agricultural Society's Show at Stirling. The property of, and bred by, Her Majesty Queen Victoria, the Prince Consort's Shaw Farm, Windsor.

PLATE 8



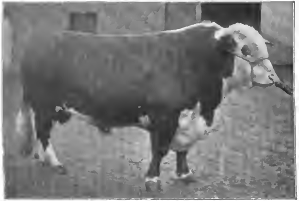
HEREFORD COW, "TRUTHFUL."

1st Prize, Royal Agricultural Society's Shows, Manchester, 1897; Birmingham, 1898; Maidstone, 1899. 1st Prize, Royal Counties Agricultural Society's Show, Winchester. 1900. The property of, and bred by, Her Majesty Queen Victoria, Flemish Farm, Windsor.



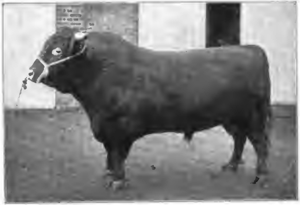
DEVON COW, "PRETTY."

The property of Her Majesty Queen Victoria, Flemish Farm, Windsor; bred by Mr. F. G. Dalgety, Lockerley Hall, Romsey, Hants. (Never exhibited.)



HEREFORD BULL, "EARLSFIELD."

The property of Her Majesty Queen Victoria, Flemish Farm, Windsor; bred by Mr. L. L. Moore, Brampton Brian, Herefordshire. (Never exhibited.)



DEVON BULL, "QUANTOCK JUBILEE."

The property of Her Majesty Queen Victoria, Flemish Farm, Windsor; bred by Mr. E. J. Stanley, M.P., Quantock Lodge, Bridgwater. (Never exhibited.)

Mr Duthie, of Collynie, Aberdeenshire, bought some of the older cows, whilst Mr Deane Willis, of Bapton Manor, Wilts, bought the yearling heifers. Mr Duthie thereupon resumed the sales that the Cruickshanks had relinquished, his averages being £30 in 1892, about £50 in 1893-94, and £80 in 1895. These prices advanced through English breeders requiring a little change of blood, and also through the increasing tendency to exhibit animals of great substance, or rather to feed animals for show. The success of this movement has strengthened the demand, whilst an inquiry for this line of blood has arisen in the United States and Canada. A faithful contemporary history of the Shorthorn breed is to be found in *Thornton's Circular*, which is published quarterly and dates back to 1868.

The *Hereford* breed is maintained chiefly in Herefordshire and the adjoining counties. Whilst a full red is the general colour of the body, the Herefords are distinguished by their white faces, white chest and abdomen, and white mane. The legs up to the knee or hock are also often white. The horns are moderately long, springing straight from the head in the bull, and turning somewhat forward and upward in the cow. Herefords, though they rear their own calves, have acquired but little fame as dairy cattle. They are, however, very hardy, and produce beef of excellent quality. As, moreover, they are docile they fatten easily and readily, and as graziers' beasts they are in high favour.

The *Devon* cattle—the "Rubies of the West," as they are termed, in allusion to their colour—are reared chiefly in Devon and Somerset. The colour is a whole red, its depth or richness varying with the individual, and in summer becoming mottled with darker spots. The Devons stand somewhat low; they are neat, compact, and plump, and possess admirable symmetry. Whilst they do not attain the size of the Shorthorn or the Hereford, yet, taking their height into consideration, they perhaps weigh better than either. In the male animal the thick-set horns project straight out at right angles to the rest of the body; in the female they are more slender, and often curve neatly upwards. Being fine-limbed, active animals, they are well adapted for grazing the poor pastures of their native hills, and they turn their food to the best account, yielding excellent beef. They have not yet attained much celebrity as milch kine, for, though their milk is of first-class quality, its quantity is usually small. Latterly, however, the milking qualities have received more attention from breeders, whose object is to qualify the Devon as a dual-purpose breed.

The *South Devon* or *South Hams* cattle are almost restricted to that southern part of the county of Devon known as the Hams, whence they are also called "Hammers." With a somewhat ungainly head, lemon-yellow hair, yellow skin, and large but hardly handsome udder, the South Devon breed bears far more resemblance to the Guernseys than to the trim-built cattle of the hills of North Devon. The cows are heavy milkers, and furnish excellent butter. They are rarely seen outside their locality, and seldom appear in the showyards.

The *Sussex* breed, named after its native county, resembles the Devon in many respects. The Sussex cattle, however, are bigger, less refined in appearance, less graceful in outline, and of a deeper brown-chestnut colour than the Devons,—the "dainty Devons," as the latter may well be called in comparison with the massive animals of the Sussex breed. As a hardy race, capable of thriving on poor rough pastures, the Sussex are highly valued in their native districts, where they have been rapidly improved in recent years. They are essentially a beef-producing breed, the cows having little reputation as milkers. By stall-feeding they can be ripened off for the butcher at an early age. The Sussex cattle are said to "die well," that is, to yield a large proportion of meat in the best parts of the carcass.

In the *Welsh* breed of cattle black is the prevailing colour, and the horns are long. They do not mature very rapidly, but some of them grow eventually into big ponderous beasts, and their beef is of prime quality. In Wales several varieties are recognized—the Anglesey, Pembroke, Glamorgan—and the cows often acquire considerable reputation as milkers. As graziers' beasts Welsh cattle are well known in the midland counties of England, where, under the name of Welsh runts, large herds of bullocks are fattened upon the pastures, or "topped up" in the yards in winter.

In the *Longhorn* breed of cattle the interest is largely historical. It was with the Longhorns that the famous Robert Bakewell, of Dishley, Leicestershire (1726-95), gave evidence of his remarkable skill as an improver of cattle in the middle of the 18th century.[1] At one period the Longhorns were widely spread in England and Ireland, but, as the Shorthorns extended their domain, the long-horned cattle made way for them. Longhorns are to be seen in the midland counties of England, chiefly in Warwickshire. They are big, rather clumsy animals, with long drooping horns, which are very objectionable in these days of cattle transport by rail and sea, and which sometimes grow in such a fashion as to prevent the animals from grazing. The bullocks feed up to high weights, and the cows are fair milkers. No lover of cattle can view these quaint creatures without a feeling of satisfaction that efforts are being made to resuscitate a breed which has many useful qualities to commend it.

The *Red Polled* is the only hornless breed of English cattle, and, though an old breed, it is within quite recent years that it has come into prominence. These cattle were formerly known as the East Anglian Polls, and later as the Norfolk and Suffolk Polled cattle, being confined chiefly to the two counties named. They are symmetrically-built animals, of medium size, and of uniformly red colour. They have a tuft of hair on the poll, or upper part of the forehead. Of the native breeds of England, the Red Polled have acquired the highest distinction as dairy cattle, and are noted for the length of the period during which they continue in milk. Not less are they valued as beef-producers, and, as they are hardy and docile, they fatten readily and mature fairly early. Hence, like the Shorthorn, they may claim to be a dual-purpose breed. As beef cattle they are always seen to advantage at the Norwich Christmas cattle show, held annually in November.

The *Aberdeen-Angus* breed belongs to Aberdeenshire and adjacent parts of Scotland, but many herds are maintained in England and some in Ireland. They possess glossy black coats (occasionally red), have no horns, and are often termed "Doddies." They attain great size and weight, make first-class beasts for the butcher, and yield beef of excellent quality. The cross between the Shorthorn and the Aberdeen-Angus, known as the "Blue Grey," is a favourite in the meat markets.

The *Galloways* are named from the district in the south-west of Scotland to which they are native. Like the Aberdeen-Angus cattle, the Galloways are hornless, and normally of a black colour. But the Galloway, with its thicker hide and shaggy hair, suited to a wet climate, has a coarser appearance than the Aberdeen-Angus, the product of a less humid region, though it approaches the latter in size. The Galloways yield superior beef, but they mature less rapidly than the Aberdeen-Angus. The

---

[1] Housman, "Robert Bakewell," *Jour. Roy. Agric. Soc.* 1894.

Galloways make admirable beasts for the grazier, and the cross between the Galloway and the Shorthorn, also known as "Blue Grey," is much sought after by the butcher.

The *Highland* breed—termed also the West Highland and the Kyloe—is perhaps the most picturesque of the breeds of British cattle. Their home is amidst the wild romantic scenery of the Highland counties and Western Isles of Scotland, though herds of them may be seen in various English parks. There is no hardier breed. In their native haunts they live exposed to all weathers, and thrive upon scanty herbage which they gather with great effort. They have not made much progress towards early maturity, but their slowly ripened beef is of the choicest quality. Whilst they are not often remarkable for size, they look larger than they really are on account of the thick shaggy hair in which they are enveloped. The colour varies from light dun, or tawny yellow, to black. Their long, handsomely curved horns are set widely apart.

The *Ayrshires* are the dairy breed of Scotland, where they have considerably overstepped the limits of the humid western county whence they take their name. They are usually of a white and brown colour, the patches being well defined. Sometimes the brown is replaced by red, and any one of the colours may prevail to the exclusion of the others. The neat, shapely, upstanding horns, with a peculiar curve upwards at the tip, are characteristic. The Ayrshires are of medium size and are graceful movers, and the females have the wedge-shape possessed by typical dairy cows. They are a hardy breed, and give good yields of milk even from poor pastures. The milk of the Ayrshires is especially useful for cheesemaking purposes.

The *Jerseys* are a breed of graceful, deer-like cattle whose home is in the island of Jersey, where, by means of stringent regulations against the importation of cattle, the breed has been kept pure for many generations. As its milk is especially rich in fat, the Jersey has attained a wide reputation as a butter-producing breed. It is a great favourite in England, where many pure-bred herds exist. The colours most preferred are the light silver-grey, the brown, and the fawn; brindled markings are very rarely seen. The white zone behind the black muzzle gives to these cattle the appearance in respect of which they are sometimes termed "mealy-mouthed." The horns are short, and generally curved inwards; the bones are fine. The best milch cows have a yellowish circle round the eye, and the skin at the extremity of the tail of a deep yellow, almost orange, colour. The Jersey cattle possess peculiarities of colour not seen in any other breed in the British Isles. The cows are gentle and docile, but the bulls, despite their small size, are often fierce.

The *Guernsey* cattle have their native homes in the islands of Guernsey, Alderney, Sark, and Herm, and they are kept pure there by the same kinds of restrictions as are adopted in Jersey for the protection of the native breed of that island. Herds of pure-bred Guernseys exist in the Isle of Wight and in various southern counties of England. They have not the refined and elegant appearance of the Jerseys, which, however, they exceed in size. They are usually of a rich yellowish-brown colour, patched with white, whilst in some cases their colour almost merits the appellation of "orange and lemon." The yellow colour inside the ears is a point always looked for by judges. The cows, large-bellied and narrow in front, are truly wedge-shaped, the greatly developed milk-bag adding to the expanse of the hinder part of the body. They yield an abundance of milk, rich in fat, so that, like the Jerseys, they are excellent butter-producers. The horns are yellow at the base, curved, and not coarse. The nose is free from black markings, whereas, in the Jerseys, there is, as has just been stated, a dark muzzle, encircled by a light colour, thus giving a "mealy-mouthed" appearance.

The *Kerry* is a breed of small black cattle belonging to the south-west of Ireland, whence they have spread into many parts, not only of their native land, but of England as well. Although they are able to subsist on the roughest and scantiest of fare, and are exceedingly hardy, the cows are, nevertheless, excellent milkers, and have acquired celebrity as a dairy breed. The colour is black, but the cows sometimes have a little white on the udder. The horns are white, with black tip, and are turned upwards. The Kerry is active and graceful, long and lithe in body, and light-limbed.

The *Dexter* breed is an offshoot of the Kerry, its origin being attributed to Mr Dexter, who is credited with having established it, by selection and breeding from the best mountain types of the Kerry. Until recently it was called the Dexter Kerry. It is smaller, shorter in the leg, and more compact than the Kerry, and gains in plumpness what it loses in elegance. Whilst valuable as a beef-making animal, it is equally noted for its milk-producing capacity. Black is the usual colour, but red is also recognized, with, in either case, a little white. When of a red colour, its appearance has been aptly compared to that of a grand Shorthorn viewed through the wrong end of a telescope. The Kerry and the Dexter are readily distinguishable. The Kerry has a light, deer-like head and horn, light limbs, with ribs, hips, and shoulders well set, thin skin, straight back, light, well-set tail, with long brush. The Dexter has, as has just been intimated, very much the character of a diminutive Shorthorn, with short strong legs, square body, flat back, thick shoulder, short neck, and well-set head and horn.

The breeds of cattle which are more especially noteworthy as beef-makers include the Shorthorn, Hereford, Devon, Sussex, Welsh, Aberdeen-Angus, Galloway, and Highland. As milk-producers, and therefore as dairy cattle, the Shorthorn, South Devon, Longhorn, Red Polled, Ayrshire, Jersey, Guernsey, Kerry, and Dexter breeds have acquired eminence. Such breeds as the Shorthorn, Devon, Welsh, Red Polled, and Dexter are claimed as useful both for beef-making and for milk-producing, and are hence regarded as serving the dual purpose. As regards colour, red is characteristic of the Hereford, Devon, Sussex, and Red Polled. Black is the dominating colour of the Welsh, Aberdeen-Angus, Galloway, Kerry, and Dexter. A yellowish colour is seen in the Guernsey and South Devon breeds. Various shades of fawn colour are usual in the Jersey cattle. The Herefords, though with red bodies, have white faces, manes, and dew-laps, whilst white prevails to a greater or less extent in the Shorthorn, Longhorn, and Ayrshire breeds. The Shorthorn breed is exceedingly variable in colour; pure-bred specimens may be red, or white, or roan, or may be marked with two or more of these colours, the roan resulting from a blending of the white and red. Black is not seen in a pure-bred Shorthorn. With respect to size and weight, the biggest and heaviest cattle come from the beef-making breeds, and are often cross-bred. Very large beasts, if pure-bred, usually belong to one or other of the Shorthorn, Hereford, Sussex, Welsh, Aberdeen-Angus, and Galloway breeds. The Devon, Red Polled, and Guernsey are medium-sized cattle; the Ayrshires are smaller. The Jerseys are small, graceful cattle, but the Kerries and Dexters furnish the smallest cattle of the British Isles.

Sheep.

The sheep native to the British Isles may be classified as longwool, shortwool, and mountain breeds. The *longwool* breeds are the Leicester, Border Leicester, Cotswold,

The property of Mr. Garrett Tay

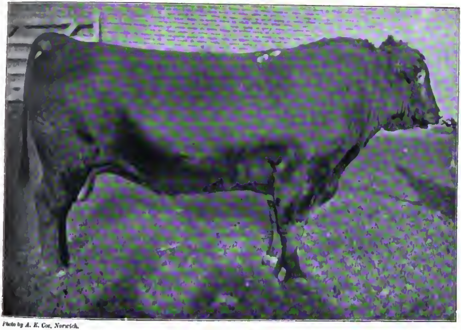


Photo by A. E. Coe, Norwich.

RED POLLED BULL, "REDMOND."

The property of Mr. Garrett Taylor, Trowse House, Norwich; bred by Mr J. J. Colman, Carrow House, Norwich.

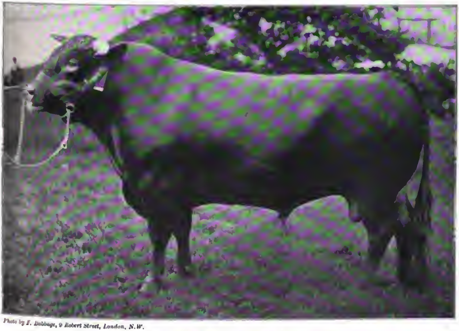


Photo by F. Babbage, 9 Robert Street, London, N.W.

SOUTH DEVON BULL, "COUNTY COUNCILLOR."

1st Prize, Bath and West Society's Show, Exeter, 1899. The property of Mr. T. B. Bolitho, M.P., Trewidden, Penzance; bred by Mr. J. P. Garland, Stockadon, Aveton Gifford.

PLATE 10.

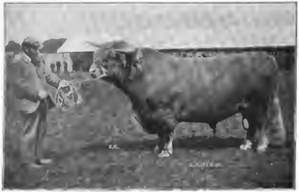


Photo by C. Reid, Wishaw, N.B.

HIGHLAND BULL, "LAOICH."

1st Prize and Champion, Highland and Agricultural Society's Shows, Perth, 1896; Glasgow, 1897; and Royal Agricultural Society's Show, York, 1900. The property of the Earl of Southesk, K.T., Kinnaird Castle, Brechin, Forfarshire; bred by Mr. John Stewart, Ensay, Portree, Inverness-shire.

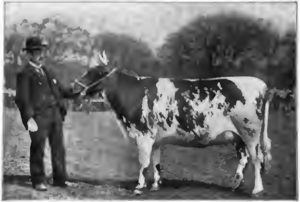


Photo by C. Reid, Wishaw, N.B.

AYRSHIRE COW, "WHITE ROSE 2ND."

1st Prize and Champion, Highland and Agricultural Society's Show, Stirling, 1900. The property of, and bred by, Mr. William Howie, Burnhouse, Galston, Ayrshire.

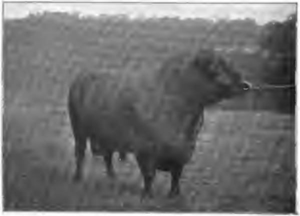


Photo by P. M. Laws, Newcastle-on-Tyne

ABERDEEN-ANGUS BULL, "BEST MAN OF BENTON."

1st Prize, Highland and Agricultural Society's Show, Kelso, 1898. The property of, and bred by, Mr. Clement Stephenson, Balliol College Farm, Long Benton, Newcastle-on-Tyne.

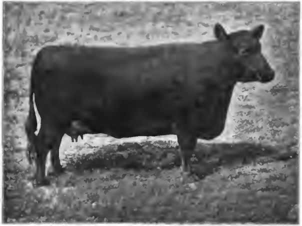


Photo by Robert Stuart, Elgin, N.B.

ABERDEEN-ANGUS COW, "LEGEND."

1st Prize and Champion, Royal Agricultural Society's Show, Darlington, 1895. The property of, and bred by, Mr. George Smith Grant, Auchorachan, Glenlivet, N.B.

Lincoln, Kentish, Devon Longwool, South Devon, Wensleydale, and Roscommon. The *shortwool* breeds are the Oxford Down, Southdown, Shropshire, Hampshire Down, Suffolk, Ryeland, Somerset and Dorset Horned, and Clun Forest. The *mountain* breeds include the Cheviot, Blackfaced Mountain, Herdwick, Lonk, Dartmoor, Exmoor, Welsh Mountain, and Limestone. These breeds are all English, except the Border Leicester, Cheviot, and Blackfaced Mountain, which belong to Scotland; the Welsh Mountain, which belongs to Wales; and the Roscommon, which is Irish. The true mountain breeds are *horned* sheep—usually the males only in the case of the Cheviot, the Herdwick, and the Welsh, though many Cheviot rams are hornless. In the only other horned breed, the Somerset and Dorset, both sexes are furnished with horns. The remaining breeds are hornless. The white-faced breeds include the Leicester, Border Leicester, Lincoln, Kentish, Cheviot, Ryeland, Devon Longwool, South Devon, Somerset and Dorset Horned, Dartmoor, Exmoor, and Roscommon. Black faces characterize the Hampshire Down and the Suffolk, whilst some amount of black is seen on the faces of the Black-faced Mountain and the Lonk.

The *Leicester*, though sparsely distributed now, is of high interest in that it was the breed which Robert Bakewell took in hand in the 18th century, and greatly improved by the exercise of his skill and judgment. Bakewell lived at Dishley Grange, Leicestershire, and in France the Leicester sheep are still called Dishleys. In past times Leicester blood was extensively employed in the improvement or establishment of other breeds of sheep. The Leicester, as seen now, has a long tapering head, projecting horizontally forwards; rather long, thin ears pointing backwards; a full broad breast; fine clean legs standing well apart; deep round barrel, with the sides diminishing in width towards the rump; thin, soft skin, covered with fine white wool; and the top of the head protected by close short wool. The breed is maintained pure upon the rich pastures of Leicestershire, Yorkshire, and adjacent counties, but its chief value is for crossing, when it is found to promote maturity and to improve the fattening propensity.

The *Border Leicester* originated after the death in 1795 of Bakewell, when the Leicester breed, as it then existed, diverged into two branches. The one is represented by the breed still known in England as the Leicester. The other, bred on the Scottish Borders, acquired the name of Border Leicester. The characteristics of the latter are a sharp profile, with dark, full nostrils, black muzzle, well-set ears, and hair on the face and poll pure white; back broad and muscular, belly well covered with wool; legs clean, and a fleece of fairly long white wool.

The *Cotswold* is an old-established breed of the Gloucestershire hills, extending thence into Oxfordshire. They are big, handsome sheep, with finely-arched necks and graceful carriage. With their broad, straight backs, curved ribs, and capacious quarters, they carry a great weight of carcase upon clean, wide-standing legs. The white silky fleece of long wavy wool gives the Cotswold an attractive appearance, which is enhanced by its stylish topknot or forelock. The mutton of the Cotswolds is not of high quality, but the sheep are useful for crossing purposes, as they impart size.

The *Lincoln* breed is descended from the old native breed of Lincolnshire, improved by the use of Leicester blood. The Lincolns are a hardy, prolific breed, but do not quite equal the Cotswolds in size. They have larger, bolder heads than the Leicesters. Breeders of Lincoln rams like a darkish face, with a few black spots on the ears. The legs should be white. The wool has a broad staple, and is denser, longer, and the fleece heavier, than in the Leicester. In 1898 Mr Henry Dudding, Riby Grove, Lincolnshire, obtained at auction the sum of 1000 guineas for a Lincoln ram bred by him, this being the highest price ever paid for a sheep in the United Kingdom. He secured the same price again for a ram in 1900.

The *Kentish* or *Romney Marsh* is a somewhat local breed, native to the rich tract of grazing land on the south coast of Kent. They are hardy, white-faced sheep, with a close-coated longwool fleece.

The *Oxford Down* is a modern breed which owes its origin to the cross-breeding of longwool and shortwool sheep, the former being Cotswolds and the latter Hampshire Downs and Southdowns. Although it has inherited the forelock from its longwool ancestors, it approximates more nearly to the shortwool type, and is accordingly classified as such. An Oxford Down ram has a bold masculine head; a poll well covered with wool, and adorned by a topknot; ears self-coloured, upright, and of fair length; face of uniform dark brown colour; legs short, dark in colour, and free from spots; back level and chest wide; and the fleece heavy and thick. The breed is popular in Oxford and other midland counties.

The *Southdown* was formerly known as the Sussex Down, as it was from the short, close pastures upon the chalky soils of the South Downs in Sussex that the breed sprang. In past times it did for the improvement of the shortwool breeds of sheep very much the same kind of work that the Leicester performed in the case of the longwool breeds. A pure-bred Southdown sheep has a small head, with a light brown or brownish grey (often mouse-coloured) face, fine bone, and a symmetrical, well-fleshed body. The legs are short and neat, the animal being of small size compared with the other Down sheep. The fleece is of fine, close, short wool, and the mutton is excellent.

The *Shropshire* is descended from the old native sheep of the Salopian hills, improved by the use of Southdown blood. Though heavier in fleece and a bulkier animal, the Shropshire has resemblance to an enlarged Southdown. As distinguished from the latter, however, the Shropshire has a darker face, blackish brown as a rule, with very neat ears, whilst its head is more massive, and is better covered with wool on the top and at the sides. This breed has made rapid strides in recent years, and it has acquired favour in Scotland and Ireland as well as abroad.

The *Hampshire Down* is another breed which owes much of its improved character to an infusion of Southdown blood. Early in the 19th century the old Wiltshire horned sheep and the Berkshire Knot roamed over the Downs of their native counties. Both these old-fashioned types have disappeared, but their descendants are seen in the modern Hampshire Down, which originated in a cross with the Southdown. Early maturity and great size have been the objects aimed at and attained, this breed, more perhaps than any other, being identified with early maturity. Whilst heavier than the Shropshire, the Hampshire Down sheep is less symmetrical. The Hampshire Downs have black faces and legs, big heads with Roman nose, darkish ears set well back, and a broad level back nicely filled in with lean meat. The mutton of the Down breeds is of superior quality.

The *Suffolk* is another modern breed, which probably took its origin in the crossing of improved Southdown rams with the old horned Norfolk ewes. The characteristics of the latter are still retained in the black face and legs of the Suffolk, but the horns have been improved away. The fleece is moderately short, the wool being of close, fine, lustrous fibre, without any tendency to mat together. The limbs, woolled to the knees and hocks, are clean below. In general appearance the Suffolk is like the Hampshire Down, from which it differs in the rather darker face, head less covered with wool, and the nose of a less pronounced Roman type.

The *Cheviot* takes its name from the range of hills extending along the boundary between England and Scotland, on both sides of which the breed now extends, though its origin has to be sought in Northumberland. The Cheviot is a hardy sheep with straight wool, of moderate length and very close-set, whilst wiry white hair covers the face and legs.

The *Black-faced Mountain* breed is chiefly reared in Scotland, but it is doubtful whether its origin is English or Scottish. Their greater hardiness, as compared with the Cheviots, has brought them into favour upon the higher grounds of the north of England and of Scotland, where they thrive upon coarse and exposed grazing lands. The colour of face and legs in this hardy mountain breed is well-defined black and white, the black predominating. The horns are low at the crown, with a clear space between the roots, and sweep away in a wide curve, sloping slightly backwards, and quite clear of the cheek. The fashionable fleece is deep, hairy, and strong, and of uniform quality throughout.

The *Lonk* has its home amongst the hills of Lancashire and Yorkshire, and it is the largest of the mountain breeds. It bears most resemblance to the Black-faced Mountain sheep, but carries a finer, heavier fleece, and is larger in head and body. Its face and legs are mottled white and black, and its horns are handsome. The tail is long and rough.

The *Herdwick* is a hardy breed thriving upon the poor mountain land in Cumberland and Westmorland. The rams sometimes have curved horns. The colour of these sheep is white, with a few darkish spots here and there; the faces and legs are often speckled. The wool is strong, coarse, and open, and inclined to be hairy about the neck. The forehead has a top-knot, and the tail is broad and bushy.

The *Wensleydale* takes its name from the Yorkshire dale (Yoredale) of which Thirsk is the centre. The Wensleydales are longwool sheep, derived from the old Teeswater breed by crossing with Leicester rams. They are dark-faced, and the head is broad and flat, with a tuft of wool on the forehead. The skin is blue, fine, and soft, whilst the wool has a bright lustre, is curled in all parts of the body, and is of uniform staple. The fore-legs are set well apart, and the hind-legs have a little fine wool below the hock.

The *Limestone* is a breed of which little is heard. It is almost restricted to the fells of Westmorland, and is probably nearly related to the Black-faced Mountain breed. The so-called "Limestones" of the Derbyshire hills are really Leicesters.

The *Welsh Mountain* is a small, active, soft-woolled, white-faced breed of hardy character. The legs are often brownish, and this colour may extend to the face. Horns may or may not be present. The mutton is of excellent quality.

The *Clun Forest* is a local breed in West Shropshire and the adjacent part of Wales. It is descended from the old tan-faced sheep that once occupied the district, and has been much crossed with the Shropshire sheep, but its wool is rather coarser than that of the latter. The first cross with the Shropshire is a favourite with butchers.

The *Ryeland* breed is so named from the Ryelands, a poor upland district in Herefordshire. It is a very old breed, against which the Shropshires have made substantial headway. The Ryeland sheep are small, hornless, have white faces and legs, and remarkably fine short wool, with a topknot on the forehead.

The *Somerset* and *Dorset Horned* is an old west-country breed of sheep. The fleece is of close texture, and the wool is intermediate between long and short, whilst the head carries a forelock. Both sexes have horns, which are very much coiled in the ram. The muzzle, legs, and hoofs are white; the nostrils are pink. This is a hardy breed, in size somewhat exceeding the Southdown. Two crops of lambs in a year are sometimes obtained from the ewes, the winter lambs being dropped from October onwards.

The *Devon Longwool* is a breed locally developed in the valleys of West Somerset, North and East Devon, and parts of Cornwall. It originated in a strong infusion of Leicester blood amongst the old Bampton stock of Devonshire. The Devon Longwool is not unlike the Lincoln, but is coarser. It is white-faced, with a lock of wool on the forehead.

The *South Devon* or *South Hams* are, like the cattle of that name, a strictly local breed, which likewise exemplify the good results of crossing with the Leicesters. The South Devons have a fairly fine silky fleece of long staple.

The *Dartmoor* is a hornless, longwool, white-fleeced sheep, with a long whitish face like that of the Leicester. It is a hardy local Devonshire breed, and is much larger than the Exmoor.

The *Exmoor* is a horned breed of Devonshire moorland sheep, probably of direct descent from the old forest or mountain breeds of England. They have white legs and faces and black nostrils. The horns curl more closely against the head than in the Somerset and Dorset breed. The Exmoors are delicately formed about the head and neck, and they have a close, fine fleece of short wool. They are very hardy, and yield mutton of choice flavour.

The *Roscommon*—the one breed of modern sheep native to Ireland—is indebted for its good qualities largely to the use of Leicester blood. It is a big-bodied sheep, carrying a long, wavy, silky fleece. It ranges mainly from the middle of Ireland westwards.

Pigs.

The classification of the native breeds of pigs compares unfavourably with that of either cattle or sheep, and in many parts of England there are nondescript animals which it would be difficult to assign to any of the recognized breeds. The latter include the Large White, Middle White, and Small White, which were all formerly embraced under the general term of Yorkshires, and are still so called in other countries. The Berkshire and the so-called Black breeds (Suffolk or Essex) are black, and the Tamworths are red.

The *Large Whites* often have a few blue spots in the skin. The head is of fair length, light in the jowls, and wide between the eyes, with somewhat drooping ears. The neck is long, but not coarse, the ribs are deep, the loin is wide and level, the tail is set high, and the legs are straight and set well outside the carcase. The whole body is covered with straight silky hair, which denotes quality and lean meat. Pigs of this breed are very prolific, and they may be grown to enormous weights.

The *Middle Whites* are built on a smaller scale than the Large Whites. They are shorter in the heads and legs, thicker and more compact in the body, and have a denser clothing of silky hair. The sows are quite as prolific as those of the Large White breed, and, as their produce matures earlier, they are much in demand for breeding porkers.

The *Small White* pigs are much smaller than the Middle Whites. The head and legs are very short, and the body, which is short, thick, and wide, is close to the ground. The jowls are heavy, the ears are pricked, and the thin skin

PLATE 11.

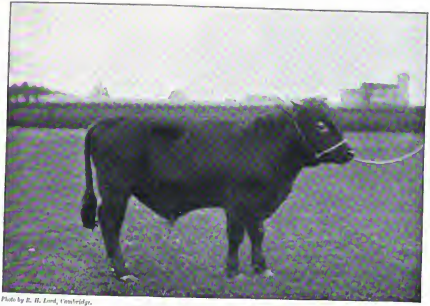


Photo by R. H. Lord, Cambridge.

Dexter Bull, "Little John" (at 9 months old).
The property of, and bred by, His Majesty King Edward VII., Sandringham, Norfolk.

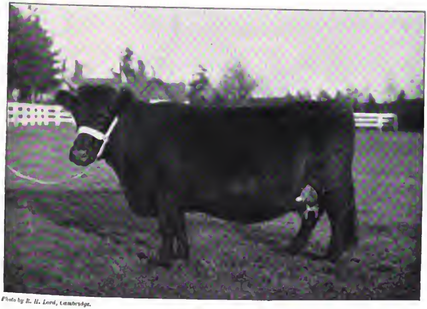


Photo by R. H. Lord, Cambridge.

Dexter Cow, "Baba."
1st Prize and Champion, Royal Agricultural Society's Shows, Cambridge, 1894; Maidstone, 1899. The property of His Majesty King Edward VII., Sandringham, Norfolk; breeder unknown.

PLATE 12.

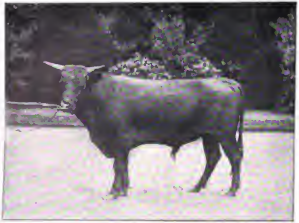


Photo by S. Victor White, Reading.

KERRY BULL, "KIDMORE PRINCE."

1st Prize, Royal Agricultural Society's Show, Doncaster, 1891. The property of, and bred by Mr. Martin J. Sutton, Kidmore Grange, Caversham, Oxon.

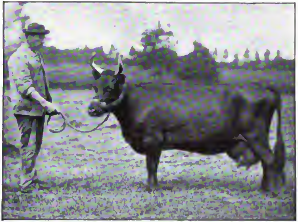


Photo by S. Victor White, Reading.

KERRY COW, "FLORA."

1st Prize, Royal Agricultural Society's Show, Newcastle-on-Tyne, 1887; London Dairy Show, 1887; and Royal Counties Agricultural Society's Show, Winchester, 1890. The property of Mr. Martin J. Sutton, Kidmore Grange, Caversham, Oxon; bred by Mr. R. Good, Aberlow, Co. Cork.

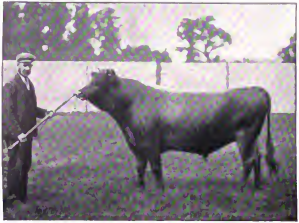


Photo by F. Babbage, 9 Robert Street, London, N.W.

JERSEY BULL, "GOLDEN MONARCH."

1st Prize, Royal Agricultural Society's Shows, Birmingham, 1898; York, 1900. The property of Mrs. Cyril E. Greenall, Walton Hall, Warrington; bred by Mr. J. Dreland, Trinity, Jersey

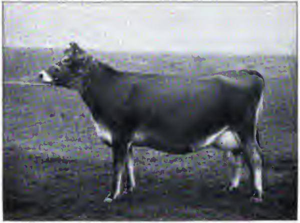


Photo by Payne and Son, Aylesbury.

JERSEY COW, "TULIP 7TH."

1st Prize, Royal Counties Agricultural Society's Show, Windsor, 1899. The property of, and bred by, Lord Rothschild, Tring Park, Herts.

is laden with long silky hair, wavy, but not curly, whilst the tail is very fine. A deficiency of lean meat is a common characteristic of the breed.

The *Small Black* (Suffolk or Essex) breed resembles the Small White, except that the skin is coal-black in colour, and the coat of hair is not usually profuse. The Small Black, moreover, is rather longer, and stands somewhat higher, whilst it yields more lean meat than the Small White. It matures early and is quick to fatten. A closely similar pig to this of the eastern counties of England thrives in Dorset, Devon, and Cornwall.

The *Large Black* breed has only recently received show-yard recognition, but it is claimed that there is ample evidence that, with its characteristic whole colour, length, fine hair, lop ear, and great grazing capacity, the Large Black existed in many parts of England long previously to the memory of any of the present generation of breeders. It has been continuously and carefully bred in Cornwall, Devon, Essex, Suffolk, and more recently in Yorkshire, Somerset, Norfolk, and Hampshire. Large Blacks are exceedingly docile, and the natural carriage of the ears, well forward over the eyes, is said to contribute materially to a quietness of habit which renders them peculiarly adapted to field grazing. On account of their hardiness and disposition to early maturity they have proved valuable for crossing purposes in Cumberland, Yorkshire, and other counties. The Large Black Pig Society was incorporated so recently as 1899.

The *Berkshire*, though a black pig, usually has a white blaze or mark down the face, a white tip to the tail, and feet white up to the ankle joint. It has a moderately short head with heavy jowls, a deep carcase, wide, low, and well-developed hind-quarters, with heavy hams. The skin is free from rucks and lines, and carries an abundance of fine hair.

The *Tamworth* is one of the oldest breeds of pigs. The colour is red, with darkish spots on the skin. The head, body, and legs are long, and the ribs are deep and flat. Originally a local breed in the districts around the Staffordshire town from which it takes its name, it is now much more extensively bred, and is valued as a bacon pig.

The enormous imports of bacon and hams into the United Kingdom—amounting in the year 1900 to 7,443,918 cwt., valued at £15,995,786—has led to the bestowal of greater attention upon the bacon-producing industry at home. In spite of all foreign competition, English bacon and hams command the highest prices, for there is something in the English method of feeding and curing which is equivalent to an addition of so many shillings per cwt. to the price. Much information on this subject is contained in the papers[1] by Mr L. M. Douglas, which may be consulted for fuller details.

BREED SOCIETIES.

A noteworthy feature of the closing decades of the 19th century was the formation of voluntary associations of stockbreeders, with the object of promoting the interests of the respective breeds of live stock. As a typical example of these organizations the Shire Horse Society may be mentioned. It was incorporated in 1878 to improve and promote the breeding of the Shire or old English race of cart horses, and to effect the distribution of sound and healthy sires throughout the country. Up to the year 1901 inclusive the society had held twenty-two annual shows in London, and had distributed prizes of an aggregate value of nearly £19,000, besides offering gold and silver medals for competition amongst Shire horses at agricultural shows in different parts of the country. Twenty-two annual volumes of the *Shire Horse Stud Book* had been published, recording the pedigrees of 19,275 stallions and 34,578 mares, or a total of 53,853 animals. In 1901 the society possessed more than 3000 members, paying an annual subscription of one guinea, or a life composition of ten guineas. It is out of the funds thus obtained that the society has carried on a work of high national importance, and has effected a marked improvement in the character and quality of the Shire horse. What has thus voluntarily been done in England would in most other countries be left to the state, or would not be attempted at all. It is hardly necessary to say that the Shire Horse Society has never received a penny of public money, nor has any other of the voluntary breeders' societies. The Hackney Horse Society and the Hunters' Improvement Society are conducted on much the same lines as the Shire Horse Society, and, like it, they each hold a show in London in the spring of the year and publish an annual volume. Other horse-breeders' associations, all doing useful work in the interests of their respective breeds, are the Suffolk Horse Society, the Clydesdale Horse Society, the Yorkshire Coach Horse Society, the Cleveland Bay Horse Society, the Polo Pony Society, the Shetland Pony Stud Book Society, and the Association for the Improvement of New Forest Ponies. Thoroughbred race-horses are registered in the General Stud Book. The Royal Commission on Horse Breeding, which dates from 1887, is, as its name implies, not a voluntary organization. Through the commission the money previously spent upon Queen's Plates is offered in the form of "Queen's Premiums" ("King's Premiums" in 1901 and subsequent years) of £150 each for thoroughbred stallions, on condition that each stallion winning a premium shall serve not less than fifty half-bred mares, if required. The winning stallions are distributed in districts throughout Great Britain, and the use of these selected sires has resulted in a decided improvement in the quality of half-bred horses. The annual show of the Royal Commission on Horse Breeding is held in London jointly and concurrently with those of the Hunters' Improvement Society and the Polo Pony Society. At the 1901 show 29 premiums of £150 were offered for thoroughbred stallions over 4 years old and not exceeding 20 years.

Of organizations of cattle-breeders the English Jersey Cattle Society, established in 1878, may be taken as an illustrative type. It offers prizes in butter-test competitions and milking trials at various agricultural shows, and publishes the *English Herd Book and Register of Pure-bred Jersey Cattle*, of which the tenth volume was issued in 1899. This volume records the births in the herds of members of the society, and gives the pedigrees of 1178 cows and 337 bulls, besides furnishing lists of prize-winners at the principal shows and butter-test awards, and reports of sales by auction of Jersey cattle. Other cattle societies, all well caring for the interests of their respective breeds, are the Shorthorn Society of Great Britain and Ireland, the Lincolnshire Red Shorthorn Association, the Hereford Herd Book Society, the Hereford Cattle Breeders' Association (the two last-named are now amalgamated), the Devon Cattle Breeders' Society, the South Devon Herd Book Society, the Sussex Herd Book Society, the Longhorned Cattle Society, the Red Polled Society, the English Guernsey Cattle Society, the English Kerry and Dexter Cattle Society, the North Wales Black Cattle Society, the Polled Cattle Society (for the Aberdeen-Angus breed), the English Aberdeen-Angus Cattle Association, the Galloway Cattle Society, the Ayrshire Cattle Herd Book Society, and the Highland Cattle Society of Scotland.

---

[1] "Bacon Curing," *Jour. Roy. Agric. Soc.*, 1898; and "The Construction of a Modern Bacon Factory," *Ibid.* 1900.

In the case of sheep the National Sheep Breeders' Association looks after the interests of flockmasters in general, whilst most of the pure breeds are represented also by separate organizations. The Hampshire Down Sheep Breeders' Association may be taken as a type of the latter, its principal object being to encourage the breeding of Hampshire Down sheep at home and abroad, and to maintain the purity of the breed. It publishes an annual Flock Book, the first volume of which appeared in 1890. In this book are named the recognized and pure-bred sires which have been used, and ewes which have been bred from, whilst there are also registered the pedigrees of such sheep as are proved to be eligible for entry. Prizes are offered by the society at various agricultural shows where Hampshire Down sheep are exhibited. Other sheep societies include the Leicester Sheep Breeders' Association, the Cotswold Sheep Society, the Lincoln Longwool Sheep Breeders' Association, the Oxford Down Sheep Breeders' Association, the Shropshire Sheep Breeders' Association and Flock Book Society, the Southdown Sheep Society, the Suffolk Sheep Society, the Border Leicester Sheep Breeders' Society, the Wensleydale Longwool Sheep Breeders' Association and Flock Book Society, the Incorporated Wensleydale Blue-faced Sheep Breeders' Association and Flock Book Society, the Kent Sheep Breeders' Association, the Devon Longwool Sheep Breeders' Society, the Dorset Horn Sheep Breeders' Association, the Cheviot Sheep Society, and the Roscommon Sheep Breeders' Association.

The interests of pig breeders are the care of the National Pig Breeders' Association, in addition to which there exist the British Berkshire Society and the Large Black Pig Society.

The addresses of the secretaries of the various live-stock societies in the United Kingdom are published annually in the *Live Stock Journal Almanac.*

THE MAINTENANCE OF THE HEALTH OF LIVE STOCK.

It was not till the closing decade of the 19th century that the stock-breeders of the United Kingdom found themselves in a position to prosecute their industry free from the fear of the introduction of contagious disease through the medium of store animals imported from abroad for fattening on the native pastures. By the Diseases of Animals Act, 1896 (59 & 60 Vict. c. 15), it was provided that cattle, sheep, and pigs imported into the United Kingdom should be slaughtered at the place of landing. The effect was to reduce to a *minimum* the risk of the introduction of disease amongst the herds and flocks of the country, and at the same time to confine the trade in store stock exclusively to the breeders of Great Britain and Ireland. This arrangement makes no difference to the food-supply of the people, for dead meat continues to arrive at British ports in ever-increasing quantity. Moreover, live animals are admitted freely from certain countries, provided such animals are slaughtered at the place of landing. At Deptford, for example, large numbers of cattle and sheep which thus arrive—mainly from Argentina, Canada, and the United States—are at once slaughtered, and so furnish a steady supply of fresh-killed beef and mutton. The animals which are shipped in this way are necessarily of the best quality, because the freight on a superior beast is no more costly than on an inferior one, and the proportion of freight to sale price is therefore less. With this superior description of butchers' stock all classes of home-grown stock—good, bad, and indifferent—have, of course, to compete. The Board of Agriculture has the power to close the ports of the United Kingdom against live animals from any country in which contagious disease is known to exist. This accounts for the circumstance that so few countries—none of them in Europe—enjoy the privilege of sending live animals to British ports. So recently as 1900, the discovery early in that year of the existence of foot-and-mouth disease amongst cattle and sheep shipped from Argentina to the United Kingdom led to the issue of an order, by which all British ports were closed against live animals from the country named. This order came into force on 30th April, and was still in operation a year later, with the result that there was a marked decline in the shipments of live cattle and sheep from the River Plate, but a decided increase in the quantity of frozen meat sent thence to the United Kingdom.

The last quarter of the 19th century witnessed an important change in the attitude of public opinion towards legislative control over the contagious diseases of animals. When, after the introduction of cattle plague or rinderpest in 1865, the proposal was made to resort to the extreme remedy of slaughter in order to check the ravages of a disease which was pursuing its course with ruinous results, the idea was received with public indignation and denounced as barbarous. Views have undergone profound modification since then, and the most drastic remedy has come to be regarded as the most effective, and in the long run the least costly. The Cattle Diseases Prevention Act, 1866 (29 & 30 Vict. c. 2), made compulsory the slaughter of diseased cattle, and permitted the slaughter of cattle which had been exposed to infection, compensation being provided out of the rates. The Act 30 & 31 Vict. c. 125, 1867, is of historical interest, in that it contains the first mention of pleuro-pneumonia, and the exposure in any market of cattle suffering from that disease was made an offence. The Contagious Diseases (Animals) Act, 1869 (32 & 33 Vict. c. 70), revoked all former Acts, and defined disease to mean cattle plague, pleuro-pneumonia, foot-and-mouth disease, sheep-pox, sheep-scab, and glanders, together with any disease which the Privy Council might by order specify. The principle of this Act in regard to foreign animals was that of free importation, with power for the Privy Council to prohibit or subject to quarantine and slaughter, as circumstances seemed to require. The Act of 1869 was at that time the most complete measure that had ever been passed for dealing with diseases of animals. The re-introduction of cattle plague into England in 1877 led to the passing of the Act 41 & 42 Vict. c. 74, 1878, which repealed the Act of 1869, and affirmed as a principle the landing of foreign animals for slaughter only, though free importation or quarantine on the one hand and prohibition on the other were provided for in exceptional circumstances. By an Order of Council which came into operation in December 1878, swine fever was declared to be a disease for the purposes of the Act of that year. It was not, however, till October 1886 that anthrax and rabies were officially declared to be contagious diseases for the purposes of certain sections of the Act of 1878. In 1884 the Act 47 & 48 Vict. c. 13 empowered the Privy Council to prohibit the landing of animals from any country in respect of which the circumstances were not such as to afford reasonable security against the introduction of foot-and-mouth disease. After one or two other measures of minor importance came the Act 53 & 54 Vict. c. 14, known as the Pleuro-pneumonia Act of 1890, which transferred the powers of local authorities to slaughter and pay compensation in cases of pleuro-pneumonia to the Board of Agriculture, and provided further for the payment of such compensation out of money specifically voted by Parliament. This measure was regarded at the time as a marked step in advance, and was only carried after a vigorous campaign in its favour. In 1892, by the Act

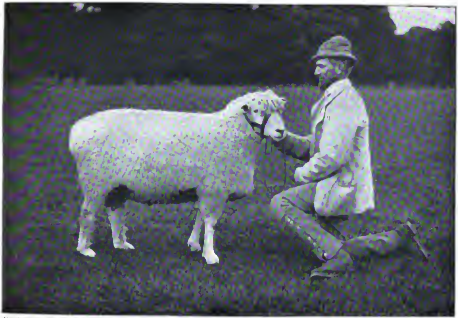


Photo by C. Reid, Wishaw, N.B.

COTSWOLD RAM.

1st Prize, Royal Agricultural Society's Show, Warwick, 1892. The property of, and bred by, Mr. Robert Garne, Aldsworth, Northleach, Gloucestershire.

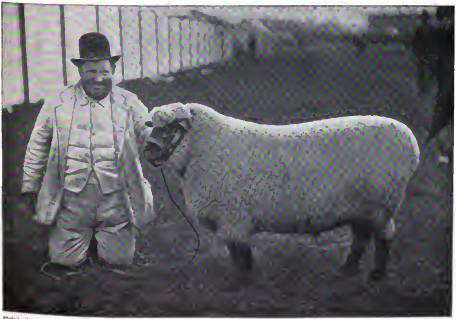


Photo by C. Reid, Wishaw, N.B.

OXFORD DOWN RAM.

1st Prize, Royal Agricultural Society's Show, York, 1900. The property of, and bred by, Mr. James T. Hobbs, Maisey Hampton, Fairford, Gloucestershire.

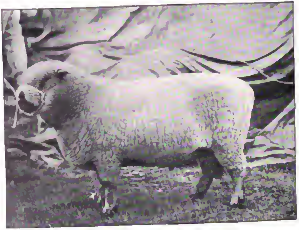
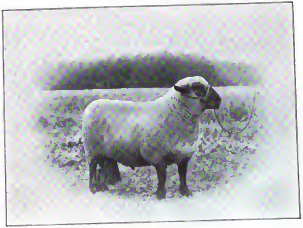


Photo by J. T. Newman, Berkhamsted

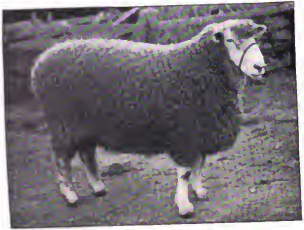
SHROPSHIRE RAM.

1st Prize, Royal Agricultural Society's Show, Maidstone, 1899. The property of, and bred by, Mr. Andrew E. Mansell, Harrington Hall, Shifnal, Salop.



HAMPSHIRE DOWN RAM.

1st Prize and Champion, Royal Counties Agricultural Society's Show, Windsor, 1899. The property of Mr. R. W. Hudson, Danesfield, Great Marlow; bred by Mr A. de Mornay, Col d'Arbres, Wallingford



LINCOLN RAM.

1st Prize and Champion, Royal Agricultural Society's Show, Birmingham, 1898. The property of, and bred by, Mr. Henry Dudding, Riby Grove, Great Grimsby, Lincolnshire. (Sold by auction for 1000 gs., July 1898.)

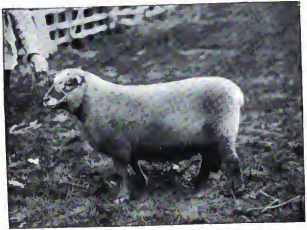


Photo by F. Babbage, 9 Robert Street, London, N.W.

SOUTHDOWN RAM.

1st Prize and Champion, Royal Agricultural Society's Show, Maidstone, 1899. The property, of and bred by, the Duke of Richmond and Gordon, K.G., Goodwood, Chichester

55 & 56 Vict. c. 47, power was given to the Board of Agriculture to use the sums voted on account of pleuro-pneumonia for paying the costs involved in dealing with foot-and-mouth disease; under this Act the Board could order the slaughter of diseased animals and of animals in contact with these, and could pay compensation for animals so slaughtered. Under the provisions of the Contagious Diseases (Animals) Act, 1893 (56 & 57 Vict. c. 43) swine fever in Great Britain was, from 1st November in that year, dealt with by the Board of Agriculture in the same way as pleuro-pneumonia, the slaughter of infected swine being carried out under directions from the central authority, and compensation allowed from the imperial exchequer. In 1894 was passed the Diseases of Animals Act (57 & 58 Vict. c. 57), the word "contagious" being omitted from the title. This was a measure to consolidate the Contagious Diseases (Animals) Acts, 1878 to 1893. In it "the expression 'disease' means cattle plague (that is to say, rinderpest, or the disease commonly called cattle plague), contagious pleuro-pneumonia of cattle (in this Act called pleuro-pneumonia), foot-and-mouth disease, sheep-pox, sheep-scab, or swine fever (that is to say, the disease known as typhoid fever of swine, soldier purples, red disease, hog cholera or swine plague)." The Diseases of Animals Act, 1896 (59 & 60 Vict. c. 15)—the last of the series of such Acts passed in the 19th century—rendered compulsory the slaughter of imported live stock at the place of landing, a boon for which British stock-breeders had striven for many years. The ports in Great Britain at which foreign animals may be landed are Bristol, Cardiff, Glasgow, Hull, Liverpool, London, Manchester, and Newcastle-upon-Tyne. Animals from the Channel Islands may be landed at Southampton.

THE DISEASES OF ANIMALS.

Under the Diseases of Animals Acts, 1894 and 1896, weekly returns are issued by the Board of Agriculture of outbreaks of anthrax, foot-and-mouth disease, glanders (including farcy), pleuro-pneumonia, rabies, and swine fever in the counties of Great Britain; also monthly returns of outbreaks of sheep-scab. There is a popular notion that tuberculosis is included amongst the diseases scheduled under the Diseases of Animals Acts, but this is not (1901) the case.

Cattle plague, or rinderpest, has not been recorded in Great Britain since 1877. In that year there were 47 outbreaks distributed over five counties, and involving 263 head of cattle.

The course of *foot-and-mouth* disease in Great Britain between 1877 and 1900 inclusive is told in Table XXII.,

TABLE XXII.—*Outbreaks of Foot-and-Mouth Disease in Great Britain*, 1877 *to* 1900.

Year.	Counties.	Outbreaks.	Animals attacked.			
			Cattle.	Sheep.	Swine.	Other Animals.
1877	55	858	5,640	7,405	2,099	
1878	45	235	912	8,609	245	
1879	29	137	261	15,681	5	
1880	38	1,461	20,918	9,572	1,886	2
1881	49	4,833	59,484	117,152	6,330	80
1882	49	1,970	23,973	11,412	2,564	1
1883	75	18,732	219,289	217,492	24,332	32
1884	55	949	12,186	14,174	1,860	1
1885	10	30	354	34	30	
1886	1	1	10			
1892	15	95	1,248	3,412	107	
1893	2	2	80			
1894	3	3	7	261		
1900	9	21	214	50	2	

from which the years 1887 to 1891 and 1895 to 1899, both inclusive, are omitted, because there was no outbreak during those periods. The disease is seen to have attained its *maximum* virulence in 1883.

Sheep-scab, a loathsome skin disease due to an acarian parasite, is in a most unsatisfactory position in Great Britain. Table XXIII. shows the number of outbreaks, and the number of counties over which they were distributed, in each year from 1877 to 1900. The outbreaks are seen to have been more numerous in the decade of the 'nineties than in that of the 'eighties, though possibly this may have been due to greater official activity in the later period. The number of sheep attacked each year has ranged between 68,715 in 1877 and 18,762 in 1888. It is compulsory on owners to notify the authorities as to the existence of scab amongst their sheep, but there is no general or well-defined method of suppressing the disorder, and the periodical dipping of sheep for the destruction of the scab parasite is not obligatory. Each year the disorder runs a similar course, the outbreaks dwindling to a *minimum* in the summer months, June to August, and attaining a maximum in the winter months, December to February. It is chiefly in the "flying" flocks and not in the breeding flocks that the disease is rife, and it is so easily communicable that a drove of scab-infested sheep passing along a road may leave behind them traces sufficient to set up the disorder in a drove of healthy sheep that may follow. For its size and in relation to its sheep population, Wales harbours the disease to a far greater extent than the other divisions of Great Britain, as the following numbers of outbreaks in the three years 1898 to 1900 serve to show:—

TABLE XXIII.—*Outbreaks of Sheep-Scab in Great Britain*, 1877 *to* 1900.

Year.	Counties.	Outbreaks.	Year.	Counties.	Outbreaks.
1877	77	3214	1889	75	1207
1878	75	2335	1890	75	1506
1879	83	2229	1891	80	2250
1880	70	1556	1892	82	2821
1881	77	2055	1893	86	2608
1882	76	2234	1894	84	2811
1883	73	1898	1895	88	3092
1884	73	1509	1896	79	3536
1885	69	1512	1897	80	2191
1886	74	1502	1898	79	2514
1887	75	1596	1899	79	2056
1888	72	1260	1900	78	1939

Year.	England.	Wales.	Scotland.	Great Britain.
1898	1342	1038	135	2515
1899	1123	791	142	2056
1900	932	917	90	1939
Total, 3 years .	3397	2746	367	6510
Per cent. .	52	43	5	100

The fatal disease known as *anthrax* did not form the subject of official returns previous to the passing of the Anthrax Order of 1886. Isolated outbreaks are of common occurrence, and from the totals for Great Britain given in Table XXIV. it would appear that there is little prospect of the eradication of this bacterial disorder.

Glanders (including farcy) has been the subject, during the twenty-four years 1877 to 1900, of outbreaks in Great Britain ranging between a *minimum* of 518 in 1877 and a *maximum* of 1657 in 1892; in the former year 758 horses were attacked, and in the latter 3001. A recrudescence of the disease marked the closing years of the 19th century, the outbreaks having been 748 in 1898, 853 in 1899, and 1119 in 1900. The counties of Great Britain over which the annual outbreaks have been distributed have ranged between 24 in 1890 and 52 in 1879. As a matter of fact, however, the disease is strongly centred upon the metropolitan area, more than half of the outbreaks being reported from the county of London alone.

Table XXIV.—*Outbreaks of Anthrax in Great Britain, 1887 to 1900.*

Year.	Counties.	Outbreaks.	Animals attacked.			
			Cattle.	Sheep.	Swine.	Horses.
1887	51	236	415	37	184	
1888	49	180	280	45	76	
1889[1]	45	167	236	4	69	
1890	48	152	253	72	210	
1891	50	226	300	15	156	
1892	60	289	445	11	190	
1893[2]	68	563	833	108	313	46
1894	64	494	625	125	188	62
1895	66	434	604	158	140	32
1896	64	488	632	34	200	38
1897	67	433	521	39	284	38
1898	73	556	634	22	161	39
1899	67	534	634	69	253	30
1900	74	571	668	40	204	44

The *Rabies* Order was passed in 1886, and the number of counties in Great Britain in which cases of rabies in dogs have been reported in each subsequent year is shown in Table XXV. In addition there have been some cases of rabies in animals other than dogs. The disease was very rife in 1895, but the extensive application of the muzzling restrictions of the Board of Agriculture was accompanied by so steady a diminution in the prevalence of the disease that it was thought the latter had been extirpated. The entire revocation of the muzzling order which accordingly followed proved, however, to be premature, and it became necessary to reimpose it in the districts where it had last been operative, namely, certain parts of South Wales.

Table XXV.—*Cases of Rabies in Dogs in Great Britain, 1887 to 1900.*

Year.	Counties.	Cases.	Year.	Counties.	Cases.
1887	28	217	1894	17	248
1888	19	160	1895	29	672
1889	20	312	1896	41	438
1890	20	129	1897	30	151
1891	17	79	1898	10	17
1892	12	38	1899	4	9
1893	18	93	1900	2	6

Pleuro-pneumonia in Great Britain was dealt with by the local authorities up to the year 1890. Between 1870 and 1889 the annual outbreaks had ranged between a *minimum* of 312 in 1884 and a *maximum* of 3262 in 1874, the largest number of cattle attacked in any one year being 7983 in 1872. The largest number of counties over which the outbreaks were distributed was 72 in 1873. On 1st September 1890, the Board of Agriculture assumed powers with respect to pleuro-pneumonia under the Diseases of Animals Act of that year. Their administration was attended by success, for from 192 outbreaks in Great Britain in 1891 the total fell to 35 in 1892, and to nine in 1893. In the four subsequent years, 1893 to 1897, the outbreaks numbered two, one, two, and seven respectively. In January 1898 an outbreak was discovered in a London cow-shed. This proved to be the last case in the 19th century of what at one time had been a veritable scourge to cattle-owners, and a source of heavy financial loss.

---

[1] In 1889 the animals attacked included 461 deer.

[2] Before 1893, horses, asses, and mules were not included in the word "animals" in the Orders relating to anthrax.

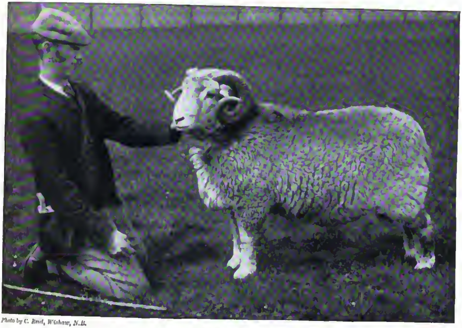


Photo by C. Reid, Wishaw, N.B.

HERDWICK RAM.

1st Prize, Royal Agricultural Society's Show, York 1900. The property of, and bred by, Mr. John Rothery, Palace Howe, Cockermouth, Cumberland.

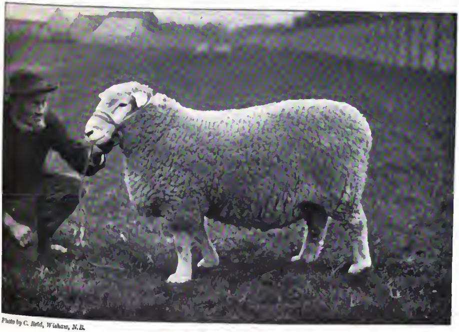


Photo by C. Reid, Wishaw, N.B.

KENTISH OR ROMNEY MARSH RAM.

1st Prize, Royal Agricultural Society's Show, York, 1900. The property of, and bred by, Mr. Frederick Neame, Macknade, Faversham, Kent.

PLATE 16.

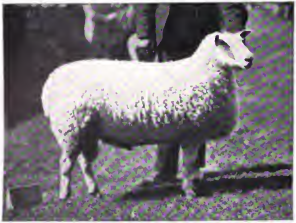


Photo by J. T. Newman, Berkhamsted.

Border Leicester Ram.

1st Prize, Royal Agricultural Society's Show, Cambridge, 1894. The property of, and bred by, the Right Hon. Arthur J. Balfour, M.P., Whittinghame, Prestonkirk, N.B.

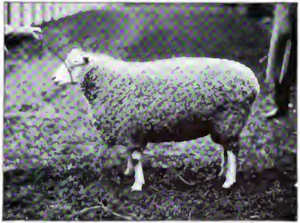


Photo by F. Babbage, 9 Robert Street, London, N.W.

Leicester Ram.

1st Prize, Royal Agricultural Society's Show, York, 1900. The property of, and bred by, Mr. E. F. Jordan, Eastburn, Driffield, East Yorkshire.

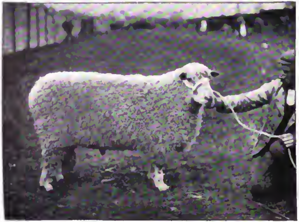


Photo by C. Reid, Wishaw, N.B.

Wensleydale Ram.

1st Prize, Royal Agricultural Society's Show, York, 1900. The property of, and bred by, the Executors of the late Mr. T. Willis, Carperby, Aysgarth, Yorkshire.

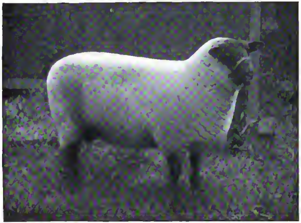


Photo by W. Vick, Ipswich.

Suffolk Wether.

1st Prize and Champion, Norwich Show, 1897. The property of, and bred by, Mr. Joseph Smith, The Grange, Walton, Ipswich.

the reciprocal trade from Great Britain to Ireland is small, and is largely restricted to animals for breeding purposes. Owing to the reappearance of foot-and-mouth disease in Great Britain early in 1900 the importation of cattle, sheep, goats, and swine therefrom into Ireland was temporarily suspended by the authorities in the latter country.

Exports of Animals from the United Kingdom.

The general export trade of the United Kingdom in living animals represents an aggregate average annual value, over the five years 1896 to 1900, of £1,017,000. To this sum of rather more than one million sterling the value of horses alone contributes three-fourths, Belgium taking more than half the number of exported horses. The export trade in cattle, sheep, and pigs is practically restricted to pedigree animals required for breeding purposes, and though its aggregate value is not large it is of considerable importance to stockbreeders, as it is a frequent occurrence for buyers for export—to Argentina, Australasia, Canada, the United States, and elsewhere—to bid freely at the sale rings, and often to pay the highest prices, thus stimulating the sales and encouraging the breeding of the best types of native stock. Details for the five years 1896 to 1900 are summarised in Table XXVIII.

Table XXVIII.—*Quantities and Values of Home-bred Live Stock exported from the United Kingdom,* 1896 *to* 1900.

Year.	Horses.	Cattle.	Sheep.	Pigs.	Other Animals.
	No.	No.	No.	No.	No.
1896	29,414	4,369	9,512	359	31,151
1897	34,471	3,776	11,569	214	42,654
1898	36,412	2,861	10,224	434	57,376
1899	33,701	2,979	7,586	938	56,381
1900	30,545	2,784	5,044	440	73,692
	£	£	£	£	£
1896	671,332	122,004	107,507	2847	38,123
1897	825,246	119,548	141,714	1700	43,744
1898	842,106	94,414	120,310	3231	43,923
1899	757,079	118,294	78,103	5281	43,723
1900	680,943	120,042	54,799	3052	45,100

Crops and Cropping.

The greater freedom of cropping and the less close adherence to the formal system of rotation of crops, which characterized the later years of the 19th century, rest upon a scientific basis. Experimental inquiry has done much to enlighten the farmer as to the requirements of plant-life, and to enable him to see how best to meet these requirements in the case of field crops. He cannot afford to ignore the results that have been gradually accumulated—the truths that have been slowly established—at the agricultural experiment stations in various parts of the world. Of these stations the greatest, and the oldest now existing, is that at Rothamsted, Harpenden, Herts, England; and it will be expedient before discussing the lessons which Rothamsted has taught, to refer briefly to the origin and scope of the work of a centre of investigation the name of which is known and honoured in all countries where progressive agriculture is practised.

Rothamsted.

The agricultural experiment station at Rothamsted was founded in 1843 by the late Sir John Bennet Lawes, and maintained at his own expense; whilst he made provision for its continuance by putting in trust during his lifetime £100,000, the laboratories, and certain areas of land, which since 1889 have been administered by the Lawes Agricultural Trust Committee. Sir J. Henry Gilbert became associated with Sir John Lawes in 1843 as director of the chemical laboratory, and the collaboration thus commenced was terminated only by the death of the founder on 31st August 1900. The results of more than half a century of sustained experimental inquiry have been communicated to the world by Lawes and Gilbert in about 130 separate papers or reports, many of which were published, from 1847 onwards, in the *Journal of the Royal Agricultural Society of England.*

Two main lines of inquiry have been followed, the one relating to plants, the other to animals. In the case of plants the method of procedure has been to grow some of the most important crops of rotation, each separately year after year, for many years in succession on the same land, (*a*) without manure, (*b*) with farmyard manure, and (*c*) with a great variety of chemical manures; the same description of manure being, as a rule, applied year after year on the same plot. Experiments on an actual course of rotation, without manure, and with different manures, have also been made. Wheat, barley, oats, beans, clover, and other leguminous plants, turnips, sugar beet, mangels, potatoes, and grass crops have thus been experimented upon. Incidentally there have been extensive sampling and analysing of soils, investigations into rainfall and the composition of drainage waters, inquiries into the amount of water transpired by plants, and experiments on the assimilation of free nitrogen.

Amongst the field experiments there is, perhaps, not one of more universal interest than that in which wheat has been grown for fifty-seven years in succession, (*a*) without manure, (*b*) with farmyard manure, and (*c*) with various artificial manures. The results show that, unlike leguminous crops such as beans or clover, wheat may be successfully grown for many years in succession on ordinary arable land, provided suitable manures be applied, and the land be kept clean. Even without manure, the average produce over forty-six years, 1852-97, was nearly thirteen bushels per acre, or more than the average yield of the whole of the United States of America, including their rich prairie lands—in fact, about the average yield per acre of the wheat lands of the whole world. Mineral manures alone give very little increase, nitrogenous manures alone considerably more than mineral manures alone, but the mixture of the two considerably more than either separately. In one case, indeed, the average produce by mixed mineral and nitrogenous manure was more than that by the annual application of farmyard manure; and in seven out of the ten cases in which such mixtures were used the average yield per acre was from over two to over eight bushels more than the average yield of the United Kingdom (assuming this to be about twenty-eight bushels of 60 lb per bushel) under ordinary rotation. It is estimated that the reduction in yield of the unmanured plot over the forty years, 1852-91, after the growth of the crops without manure during the eight preceding years, was, provided it had been uniform throughout, equivalent to a decline of one-sixth of a bushel from year to year due to exhaustion—that is, irrespectively of fluctuations due to season. It is related that a visitor from the United States, talking to Sir John Lawes, said, "Americans have learnt more from this field than from any other agricultural experiment in the world."

Another field experiment of singular interest is that relating to the mixed herbage of permanent meadow, for which seven acres of old grass land were set apart in Rothamsted Park in 1856. Of the twenty plots into which this land is divided, two have been left without manure from the commencement, two received ordinary farmyard manure for a series of years, whilst the remainder have each received a different description of artificial or chemical manure, the same being, except in special cases, applied year after year on the same plot. No one can inspect this field during the growing season without being impressed by the striking evidence it affords of the influence of different manurial dressings. So much, indeed, does the character of the herbage vary from plot to plot that the effect may fairly be described as kaleidoscopic. Repeated analyses have shown how greatly both the botanical constitution and the chemical composition of the mixed herbage vary according to the description of manure applied. They have further shown how dominant is the influence of season. Such, moreover, is the influence of different manures that the gross produce of the mixed herbage is totally different on the respective plots according to the manure employed, both as to the proportion of the various species composing it, and as to their condition of development and maturity.

The experiments with farm animals began in 1847, and amongst the points that have been investigated are the following:—(1) The amount of food, and of its several constituents, consumed (*a*) in relation to a given live weight of animal within a given time, (*b*) to produce a given amount of increase in live weight. (2) The proportion and relative development of the different organs, or parts, of different animals. (3) The proximate and ultimate composition of the animals in different conditions as to age and fatness, and the probable composition of their increase in live weight during the fattening process. (4) The composition of the solid and liquid excreta (the manure) in relation to that of the food consumed. (5) The loss or expenditure of constituents by respiration and the cutaneous exhalations—that is, in the mere sustenance of the living meat-and-manure-making machine. (6) The yield of milk in relation to the food consumed to produce it; and the influence of different descriptions of food on the quantity and on the composition of the milk.

Incidentally, the results obtained from these inquiries have furnished data essential to the consideration of such problems as (*a*) the sources in the food of the fat produced in the animal body; (*b*) the characteristic demands of the animal body—for nitrogenous or non-nitrogenous constituents of food—in the exercise of muscular power; (*c*) the comparative characters of animal and vegetable food in human dietaries.

In proceeding to discuss the various classes of crops, it will be convenient to deal with them under the three separate heads of root-crops, cereal crops, and leguminous crops, and then to inquire into their inter-relations when grown in rotation.

Root-Crops.—Experiments upon root-crops—chiefly white turnips, Swedish turnips (swedes), and mangels—have resulted in the establishment of the following conclusions. Both the quantity and the quality of the produce, and consequently its feeding value, must depend greatly upon the selection of the best description of roots to be grown, and on the character and the amount of the manures, and especially on the amount of nitrogenous manure employed. At the same time, no hard and fast rules can be laid down concerning these points. Independently of the necessary consideration of the general economy of the farm, the choice must be influenced partly by the character of the soil, but very much more by that of the climate. Judgment founded on knowledge and aided by careful observation, both in the field and in the feeding-shed, must be relied upon as the guide of the practical farmer. Over and above the great advantage arising from the opportunity which the growth of root-crops affords for the cleaning of the land, the benefits of growing the root-crop in rotation are due (1) to the large amount of manure applied for its growth, (2) to the large residue of the manure left in the soil for future crops, (3) to the large amount of matter at once returned as manure again in the leaves, (4) to the large amount of food produced, and (5) to the small proportion of the most important manurial constituents of the roots which is retained by store or fattening animals consuming them, the rest returning as manure again; though, when roots are consumed for the production of milk, a much larger proportion of the constituents is lost to the manure.

Cereal Crops—Barley and Wheat.—Experiments upon the growth of barley for nearly fifty years in succession on rather heavy ordinary arable soil have resulted in showing that the produce by mineral manures alone is larger than that without manure; that nitrogenous manures alone give more produce than mineral manures alone; and that mixtures of mineral and nitrogenous manure give much more than either used alone—generally twice, or more than twice, as much as mineral manures alone. Of mineral constituents, whether used alone or in mixture with nitrogenous manures, phosphates are much more effective than mixtures of salts of potash, soda, and magnesia. The average results show that, under all conditions of manuring—excepting with farmyard manure—the produce was less over the later than over the earlier periods of the experiments, an effect partly due to the seasons. But the average produce over forty years of continuous growth of barley was, in all cases where nitrogenous and mineral manures (containing phosphates) were used together, much higher than the average produce of the crop grown in ordinary rotation in the United Kingdom, and very much higher than the average in most other countries when so grown. The requirements of barley within the soil, and its susceptibility to the external influences of season, are very similar to those of its near ally, wheat. Nevertheless, there are distinctions of result dependent on differences in the habits of the two plants, and in the conditions of their cultivation accordingly. Wheat is, as a rule, in the British Isles sown in the autumn on a heavier soil, and has four or five months in which to distribute its roots, and so it gets possession of a wide range of soil and subsoil before barley is sown in the spring. Barley, on the other hand, is sown in a lighter surface soil, and, with its short period for root-development, relies in a much greater degree on the stores of plant-food within the surface soil. Accordingly, it is more susceptible to exhaustion of surface soil as to its nitrogenous, and especially as to its mineral supplies; and in the common practice of agriculture it is found to be more benefited by direct mineral manures, especially phosphatic manures, than is wheat when sown under equal soil conditions. The exhaustion of the soil induced by both barley and wheat is, however, characteristically that of available nitrogen; and when, under the ordinary conditions of manuring and cropping, artificial manure is still required, nitrogenous manures are, as a rule, necessary for both crops, and, for the spring-sown barley, superphosphate also. Although barley is appropriately grown on lighter soils than wheat, good crops, of fair quality, may be grown on the heavier soils after another grain crop by the aid of artificial manures, provided that the land is sufficiently clean.

Leguminous Crops and the Acquisition of Nitrogen.—The fact that the growth of a leguminous crop, such as red clover, leaves the soil in a higher condition for the subsequent growth of a grain crop—that, indeed, the growth of such a leguminous crop is to a great extent equivalent to the application of a nitrogenous manure for the cereal crop—was in effect known ages ago. The Romans recognized it two thousand years since, for Varro writes, "Certain things are to be sown, not with the hope of any immediate profit being derived from them, but with a view to the following year, because being ploughed in and then left in the ground, they render the soil after-

PLATE 17.

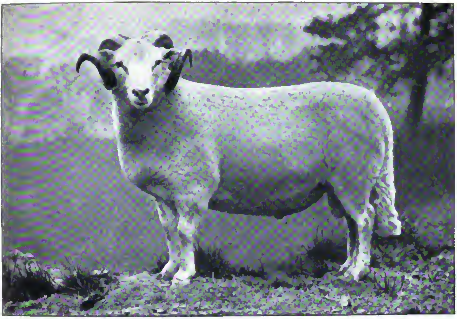


Photo by C. Reid, Wishaw, N.B.

Welsh Mountain Ram, "Hero II."

1st Prize, Royal Agricultural Society's Shows, Maidstone, 1899; York, 1900. The property of, and bred by, Mr. J. Marshall Dugdale, Llwyn, Llanfyllin, Montgomeryshire.

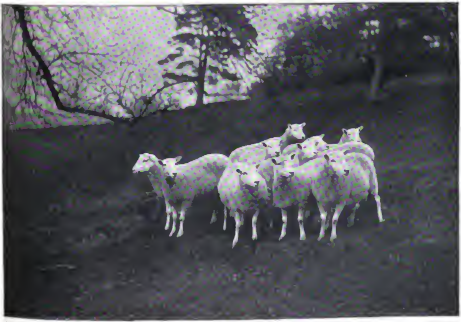


Photo by C. Reid, Wishaw, N.B.

Welsh Mountain Ewes.

1st Prize, Royal Agricultural Society's Show, Maidstone, 1899. The property of, and bred by, Mr. J. Marshall Dugdale, Llwyn, Llanfyllin, Montgomeryshire.

PLATE 18.

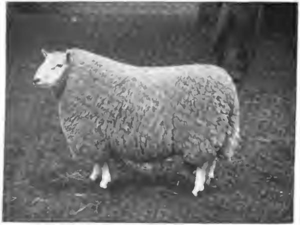


Photo by C. Reid, Wishaw, N.B.

CHEVIOT RAM

1st Prize and Champion, Highland and Agricultural Society's Shows, Glasgow, 1897; Kelso, 1898. The property of, and bred by, Mr. John Elliot, Hindhope, Jedburgh.

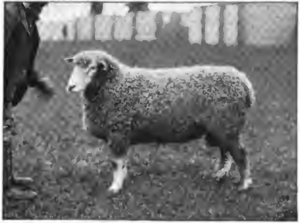


Photo by F. Babbage, 9 Robert Street, London, N.W.

DEVON LONGWOOL RAM.

1st Prize, Bath and West Society's Show, Exeter, 1899. The property of, and bred by, Mr. F. White, Torweston, Williton.

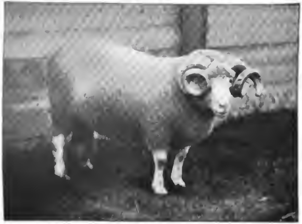


Photo by J. T. Newman, Berkhamsted.

DORSET HORNED RAM.

1st Prize, Royal Agricultural Society's Show, Maidstone, 1899. The property of, and bred by, Mr. W. R. Flower, West Stafford, Dorchester.

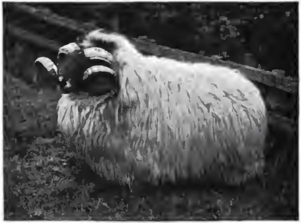


Photo by C. Reid, Wishaw, N.B.

BLACKFACED MOUNTAIN RAM, "KENDAL."

1st Prize and Gold Medal, Edinburgh Show, 1896. The property of Mr. William Byers, Baadsmill, West Calder, N.B.; bred by Mr. Thomas Dargue, Burneside Hall, Kendal.

wards more fruitful"; and the plants used for this purpose were lupins, beans, vetches, and other leguminous species. Nevertheless, it was not till near the approach of the closing decade of the 19th century that the explanation of this long-established point of agricultural practice was forthcoming. It was in the year 1886 that Hellriegel and Wilfarth first published in Germany the results of investigations in which they demonstrated that through the agency of micro-organisms dwelling in nodular outgrowths on the roots of ordinary leguminous plants the latter are enabled to assimilate the free nitrogen of the air. The existence of the root nodules had long been recognized, but hitherto no adequate explanation had been afforded as to their function.

Since Hellriegel's striking discovery farm crops have been conveniently classified as nitrogen-accumulating and nitrogen-consuming. To the former belong the ordinary leguminous crops—the clovers, beans, peas, vetches or tares, sainfoin, lucerne, for example—which obtain their nitrogen from the air, and are independent of the application of nitrogenous manures, whilst in their roots they accumulate a store of nitrogen which will ultimately become available for future crops of other kinds. It is, in fact, fully established that these leguminous crops acquire a considerable amount of nitrogen by the fixation of the free nitrogen of the atmosphere under the influence of the symbiotic growth of their root-nodule-microbes and the higher plant. The cereal crops (wheat, barley, oats, rye, maize); the cruciferous crops (turnips, cabbage, kale, rape, mustard); the solanaceous crops (potatoes); the chenopodiaceous crops (mangels, sugar beets), and other non-leguminous crops have, so far as is known, no such power, and are therefore more or less benefited by the direct application of nitrogenous manures. The field experiments on leguminous plants at Rothamsted have shown that land which is, so to speak, exhausted so far as the growth of one leguminous crop is concerned, may still grow very luxuriant crops of another plant of the same natural order, but of different habits of growth, and especially of different character and range of roots. This result is doubtless largely dependent on the existence, the distribution, and the condition of the appropriate microbes for the due infection of the different descriptions of plant, for the micro-organism that dwells symbiotically with one species is not identical with that which similarly dwells with another. It seems certain that success in any system involving a more extended growth of leguminous crops in rotations must be dependent on a considerable variation in the description grown. Other essential conditions of success will commonly include the liberal application of potash and phosphatic manures, and sometimes chalking or liming for the leguminous crop. As to how long the leguminous crop should occupy the land, the extent to which it should be consumed on the land, or the manure from its consumption be returned, and under what conditions the whole or part of it should be ploughed in—these are points which must be decided as they arise in practice. It seems obvious that the lighter and poorer soils would benefit more than the heavier or richer soils by the extended growth of leguminous crops.

Remarkable as Hellriegel's discovery was, it merely furnished the explanation of a fact which had been empirically established by the husbandman long before, and had received most intelligent application when the old four-course (or Norfolk) rotation was devised. But it gave some impetus to the practice of green manuring with leguminous crops, which are equally capable with such a crop as mustard of enriching the soil in humus, whilst in addition they bring into the soil from the atmosphere a quantity of nitrogen available for the use of subsequent crops of any kind. In Canada and the United States this rational employment of a leguminous crop for ploughing in green is being largely resorted to for the amelioration of worn-out wheat lands and other soils, the condition of which has been lowered to an unremunerative level by the repeated growth year after year of a cereal crop. The well-known paper of Lawes, Gilbert, and Pugh (1861), "On the Sources of the Nitrogen of Vegetation, with special Reference to the Question whether Plants assimilate free or uncombined Nitrogen," answered the question referred to in the negative. The attitude now taken up with regard to this problem is set forth in the following words, which are quoted from the Memoranda of the Rothamsted Experiments, 1900 (p. 7):—

> Experiments were commenced in 1857, and conducted for several years in succession, to determine whether plants assimilate free or uncombined nitrogen, and also various collateral points. Plants of the gramineous, the leguminous, and of other families, were operated upon. The late Dr Pugh took a prominent part in this inquiry. The conclusion arrived at was that our agricultural plants do not themselves directly assimilate the free nitrogen of the air by their leaves.
>
> In recent years, however, the question has assumed quite a new aspect. It now is—whether the free nitrogen of the atmosphere is brought into combination under the influence of micro-organisms, or other low forms, either within the soil, or in symbiosis with a higher plant, thus serving indirectly as a source of nitrogen to plants of a higher order. Considering that the results of Hellriegel and Wilfarth on this point were, if confirmed, of great significance and importance, it was decided to make experiments at Rothamsted on somewhat similar lines. Accordingly, a preliminary series was undertaken in 1888; more extended series were conducted in 1889 and in 1890; and the investigation was continued up to the commencement of the year 1895. Further experiments relating to certain aspects of the subject were commenced in 1898, and are still in progress. The results have shown that, when a soil growing leguminous plants is infected with appropriate organisms, there is a development of the so-called leguminous nodules on the roots of the plants, and coincidently, increased growth, and gain of nitrogen.

The Rotation of Crops.—Although many different rotations of crops are practised, they may for the most part be considered as little more than local adaptations of the system of alternating root-crops and leguminous crops with cereal crops, as exemplified in the old four-course rotation—roots, barley, clover, wheat. The rotations extending to five, six, seven, or more years are, in most cases, only adaptations of the principle to variations of soil, altitude, aspect, climate, markets, and other local conditions. They are effected chiefly by some alteration in the description of the root-crop, and perhaps by the introduction of the potato crop; by growing a different cereal, or it may be more than one cereal consecutively; by the growth of some other leguminous crop than clover, or the intermixture of grass seeds with the clover, and perhaps by the extension of the period allotted to this member of the rotation to two or more years. Whatever the specific rotation, there may in practice be deviations from the plan of retaining on the farm the whole of the root-crops, the straw of the grain crops, and the leguminous fodder crops (clover, vetches, sainfoin, &c.), for the production of meat or milk, and, coincidently, for that of manure to be returned to the land. It is equally true that, when under the influence of special local or other demand—proximity to towns, easy railway or other communication, for example—the products which would otherwise be retained on the farm are exported from it, the import of town or other manures is generally an essential condition of such practice. This system of free sale, indeed, frequently involves full compensation by purchased manures of some kind. Such deviations from the practice of merely selling grain and meat off the farm have much extended in recent years, and will probably continue to do so under the altered conditions of British agriculture, determined by very large imports of grain, increasing imports of meat and of other products of stock-feeding, and very large imports of cattle-food and other agricultural produce. More attention is thus being devoted to dairy produce, not only on grass farms, but on those that are mainly arable.

The benefits that accrue from the practice of rotation are well illustrated in the results obtained from the investigations at Rothamsted into the simple four-course system, which may fairly be regarded as a self-supporting system. Reference may first be made to the important mineral constituents of different crops of the four-course rotation. Of *phosphoric acid*, the cereal crops take up as much as, or more than, any other crops of the rotation, excepting clover; and the greater portion thus taken up is lost to the farm in the saleable product—the grain. The remainder, that in the straw, as well as that in the roots and the leguminous crops, is supposed to be retained on the farm, excepting the small amount exported in meat and milk. Of *potash*, each of the rotation crops takes up very much more than of phosphoric acid. But much less potash than phosphoric acid is exported in the cereal grains, much more being retained in the straw, whilst the other products of the rotation—the root and leguminous crops—which are also supposed to be retained on the farm, contain very much more potash than the cereals, and comparatively little of it is exported in meat and milk. Thus, the whole of the crops of rotation take up very much more of potash than of phosphoric acid, whilst probably even less of it is ultimately lost to the land. Of *lime*, very little is taken up by the cereal crops, and by the root-crops much less than of potash; more by the leguminous than by the other crops, and, by the clover especially, sometimes much more than by all the other crops of the rotation put together. Very little of the lime of the crops, however, goes off in the saleable products of the farm in the case of the self-supporting rotation under consideration. Although, therefore, different, and sometimes very large, amounts of these typical mineral constituents are taken up by the various crops of rotation, there is no material export of any in the saleable products, *excepting of phosphoric acid and of potash*; and, so far at least as phosphoric acid is concerned, experience has shown that it may be advantageously supplied in purchased manures.

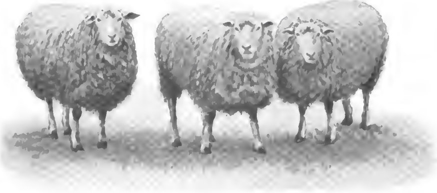
TABLE XXIX.—*The Weight and Average Composition of Ordinary Crops, in Pounds per Acre.*

Crop.	Weight of Crop.		Total Pure Ash.	Nitrogen.	Sulphur.	Potash.	Soda.	Lime.	Magnesia.	Phosphoric Acid.	Chlorine.	Silica.
	At Harvest.	Dry.										
Wheat, grain, 30 bushels . .	1,800	1530	30	34	2·7	9·3	0·6	1·0	3·6	14·2	0·1	0·6
,, straw . . .	3,158	2658	142	16	5·1	19·5	2·0	8·2	3·5	6·9	2·4	96·3
Total crop . . .	4,958	4183	172	50	7·8	28·8	2·6	9·2	7·1	21·1	2·5	96·9
Barley, grain, 40 bushels .	2,080	1747	46	35	2·9	9·8	1·1	1·2	4·0	16·0	0·5	11·8
straw . . .	2,447	2080	111	14	3·2	25·9	3·9	8·0	2·9	4·7	3·6	56·8
Total crop . . .	4,527	3827	157	49	6·1	35·7	5·0	9·2	6·9	20·7	4·1	68·6
Oats, grain, 45 bushels . .	1,890	1625	51	34	3·2	9·1	0·8	1·8	3·6	13·0	0·5	19·9
,, straw	2,835	2353	140	18	4·8	37·0	4·6	9·8	5·1	6·4	6·1	65·4
Total crop . . .	4,725	3978	191	52	8·0	46·1	5·4	11·6	8·7	19·4	6·6	85·3
Maize, grain, 30 bushels .	1,680	1500	22	28	1·8	6·5	0·2	0·5	3·4	10·0	0·2	0·5
,, stalks, &c., . .	2,208	1877	99	15	...	29·8	...	...	...	8·0		
Total crop . . .	3,888	3377	121	43	...	36·3	...	...	...	18·0		
Meadow hay, 1½ ton . .	3,360	2822	203	49	5·7	50·9	9·2	32·1	14·4	12·3	14·6	56·9
Red Clover hay, 2 tons .	4,480	3763	258	98	9·4	83·4	5·1	90·1	28·2	24·9	9·8	7·0
Beans, grain, 30 bushels .	1,920	1613	58	78	4·4	24·3	0·6	2·9	4·2	22·8	1·1	0·4
,, straw . . .	2,240	1848	99	29	4·9	42·8	1·7	26·3	5·7	6·3	4·3	6·9
Total crop . . .	4,160	3461	157	107	9·3	67·1	2·3	29·2	9·9	29·1	5·4	7·3
Turnips, root, 17 tons . .	38,080	3126	218	61	15·2	108·6	17·0	25·5	5·7	22·4	10·9	2·6
,, leaf . . .	11,424	1531	146	49	5·7	40·2	7·5	48·5	3·8	10·7	11·2	5·1
Total crop . . .	49,504	4657	364	110	20·9	148·8	24·5	74·0	9·5	33·1	22·1	7·7
Swedes, root, 14 tons . .	31,360	3349	163	70	14·6	63·3	22·8	19·7	6·8	16·9	6·8	3·1
,, leaf	4,704	706	75	28	3·2	16·4	9·2	22·7	2·4	4·8	8·3	3·6
Total crop . . .	36,064	4055	238	98	17·8*	79·7	32·0	42·4	9·2	21·7	15·1	6·7
Mangels, root, 22 tons . .	49,280	5914	426	98	4·9	222·8	69·4	15·9	18·3	36·4	42·5	8·7
,, leaf . . .	18,233	1654	254	51	9·1	77·9	49·3	27·0	24·2	16·5	40·6	9·2
Total crop . . .	67,513	7568	680	149	14·0	300·7	118·7	42·9	42·5	52·9	83·1	17·9
Potatoes, tubers, 6 tons .	13,440	3360	127	46	2·7	76·5	3·8	3·4	6·3	21·5	4·4	2·6

* Calculated from a single analysis only.

Of *nitrogen*, the cereal crops take up and retain much less than any of the crops alternated with them, notwithstanding the circumstance that the cereals are very characteristically benefited by nitrogenous manures. The root-crops, indeed, may contain two, or more, times as much nitrogen as either of the cereals, and the leguminous

PLATE 19.



ROSCOMMON EWES.

1st Prize, Royal Dublin Society's Show, 1898. The property of, and bred by, Mr. Mathew Flanagan, Tomona, Tulsk, Co. Roscommon, Ireland.

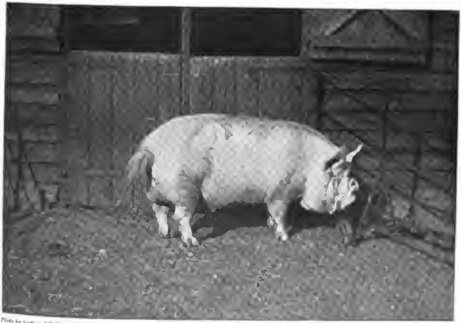
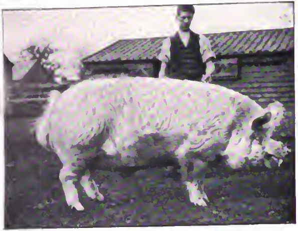


Photo by Scott and Wilkinson, Cambridge.

MIDDLE WHITE BOAR, "HOLYWELL ROSADOR."

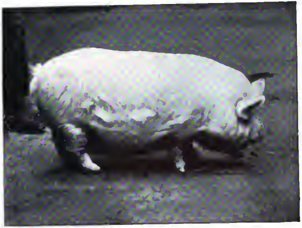
1st Prize, Highland and Agricultural Society's Show, Stirling, 1900. The property of, and bred by, Mr Sanders Spencer, Holywell Manor, St. Ives, Hunts.

PLATE 20.



Large White Boar, "Holywell Royalty II."

1st Prize, Bath and West Society's Show, Bath, 1900. The property of, and bred by, Mr. Sanders Spencer, Holywell Manor, St. Ives, Hunts.



Small White Sow.

1st Prize, Bath and West Society's Show, Bath, 1900. The property of, and bred by, the Earl of Carnarvon, Highclere Castle, Newbury, Berkshire.

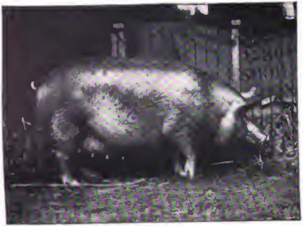


Photo by F. Babbage, 9 Robert Street, London, N.W.

Tamworth Sow, "Whitacre Beauty."

1st Prize and Champion, Royal Agricultural Society's Show, Maidstone, 1899. The property of, and bred by, Mr D. W. Philip, The Ashes, Whitacre, Coleshill, Warwickshire.

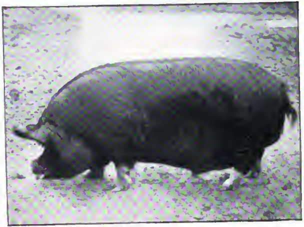


Photo by Thos. Fall, 9 Baker Street, London, W.

Berkshire Boar, "Jack of All Trades."

1st Prize, Oxfordshire Agricultural Society's Show, 1900. The property of Mr. R. W. Hudson, Danesfield, Great Marlow; bred by Mr. E. Burbidge, South Wraxhall, Bradford-on-Avon.

crops, especially the clover, much more than the root-crops. The greater part of the nitrogen of the cereals is, however, sold off the farm; but perhaps not more than 10 or 15 per cent. of that of either the root-crop or the clover (or other forage leguminous crop) is sold off in animal increase or in milk. Most of the nitrogen in the straw of the cereals, and a very large proportion of that of the much more highly nitrogen-yielding crops, returns to the land as manure, for the benefit of future cereal and other crops. As to the source of the nitrogen of the root-crops—the so-called "restorative crops"—these are as dependent as any crop that is grown on available nitrogen within the soil, which is generally supplied by the direct application of nitrogenous manures, natural or artificial. Under such conditions of supply, however, the root-crops, gross feeders as they are, and distributing a very large extent of fibrous feeding root within the soil, avail themselves of a much larger quantity of the nitrogen supplied than the cereal crops would do in similar circumstances. This result is partly due to their period of accumulation and growth extending even months after the period of collection by the ripening cereals has terminated, and at the season when nitrification within the soil is most active, and the accumulation of nitrates in it is the greatest. When a full supply of both mineral constituents and nitrogen is at command, these root-crops assimilate a very large amount of carbon from the atmosphere, and produce, besides nitrogenous food materials, a very large amount of the carbohydrate sugar, as respiratory and fat-forming food for the live stock of the farm. The still more highly nitrogenous leguminous crops, although not characteristically benefited by nitrogenous manures, nevertheless contribute much more nitrogen to the total produce of the rotation than any of the other crops comprised in it. It is the leguminous fodder crops—especially clover, which has a much more extended period of growth, and much wider range of collection within the soil and subsoil, than any of the other crops of the rotation—that yield in their produce the largest amount of nitrogen per acre. Much of this is doubtless taken up as nitrate, yet the direct application of nitrate of soda has comparatively little beneficial influence on their growth. The nitric acid is most likely taken up chiefly as nitrate of lime, but probably as nitrate of potash also, and it is significant that the high nitrogen-yielding clover takes up, or at least retains, very little soda. Table XXIX. from Warington's *Chemistry of the Farm* will serve to illustrate the subjects that have been discussed in this section.

It is not only the conditions of growth, but the *uses* to which the different crops are put, that have to be considered in the case of rotation. Thus the cereal crops, when grown in rotation, yield more produce for sale in the season of growth than when grown continuously. Moreover, the crops alternated with the cereals accumulate very much more of mineral constituents and of nitrogen in their produce than do the cereals themselves. By far the greater proportion of those constituents remains in circulation in the manure of the farm, whilst the remainder yields highly valuable products for sale in the forms of meat and milk. With a variety of crops, again, the mechanical operations of the farm, involving horse and hand labour, are better distributed over the year, and are therefore more economically performed. The opportunities which rotation cropping affords for the cleaning of the land from weeds is another distinct element of advantage.

THE FEEDING OF ANIMALS, AND THE MANURIAL VALUE OF DIFFERENT FOODS.

In the feeding experiments at Rothamsted it has been shown that the amount of food consumed, both for a given live weight of animal within a given time, and for the production of a given amount of increase, is, as current food-stuffs go, measurable more by the amounts they contain of digestible and available non-nitrogenous constituents than by the amounts of the digestible and available nitrogenous constituents they supply. The non-nitrogenous substance (the fat) in the increase in live weight of an animal is, at any rate in great part, if not entirely, derived from the non-nitrogenous constituents of the food. Of the nitrogenous compounds in food, on the other hand, only a small proportion of the whole consumed is finally stored up in the increase of the animal—in other words, a very large amount of nitrogen passes through the body beyond that which is finally retained in the increase, and so remains for manure. Hence it is that the amount of food consumed to produce a given amount of increase in live weight, as well as that required for the sustentation of a given live weight for a given time, should—provided the food be not abnormally deficient in nitrogenous substance—be characteristically dependent on its supplies of digestible and available non-nitrogenous constituents. It has further been shown that, in the exercise of force by animals, there is a greatly increased expenditure of the non-nitrogenous constituents of food, but little, if any, of the nitrogenous. Thus, then, alike for maintenance, for increase, and for the exercise of force, the exigencies of the system are characterized more by the demand for the digestible non-nitrogenous or more specially respiratory and fat-forming constituents than by that for the nitrogenous or more specially flesh-forming ones. Hence, as current fattening food-stuffs go—assuming, of course, that they are not abnormally low in the nitrogenous constituents—they are, *as foods*, more valuable in proportion to their richness in digestible and available non-nitrogenous than to that of their nitrogenous constituents. As, however, the manure of the animals of the farm is valuable largely in proportion to the nitrogen it contains, there is, so far, an advantage in giving a food somewhat rich in nitrogen, provided it is in other respects a good one, and, weight for weight, not much more costly.

In Table XXX., which underwent revision in 1885, and was adopted as trustworthy in 1897, is shown the average composition, both per cent. and per ton, of all the leading cattle-foods. It is obvious that, in the case of almost every one of the articles enumerated, individual samples may vary even considerably from the average. In foods which are manufactured or imported the percentage of dry matter is usually high. In those which may be either imported or home-grown, the variations in the percentage of dry matter in different samples may be comparatively wide, it being as a rule distinctly higher in the imported articles, which could not be shipped unless in a drier condition than is usual with the home-grown product. In such cases the imported food will probably contain a higher, or the home-grown one a lower, percentage of dry matter than the average given in the table. Hence the figures as tabulated need to be adopted or modified with judgment, having regard to the influence of the conditions of growth, maturity, preparation, or preservation to which the foods have been subject. Unless, however, the variation from the standard composition adopted in the table be more than usual, the effect on the estimates of the manure value—for which the table is primarily intended—will not be material, though it will obviously be much greater in the case of the nitrogen than in that of either the phosphoric acid or the potash. The table is useful for purposes of comparison—for example, one ton of decorticated cotton cake contains about four times as much nitrogen as a ton of maize, wheat, or barley, and thirty times as much as a ton of mangel wurzels.

Table XXX.—*Average Composition, Per Cent. and Per Ton, of Cattle Foods.*

Foods.	Per Cent.					Per Ton.		
	Dry Matter.	Nitrogen.	Mineral Matter (Ash).	Phosphoric Acid.	Potash.	Nitrogen.	Phosphoric Acid.	Potash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	℔	℔	℔
1. Linseed	90·00	3·60	4·00	1·54	1·37	80·64	34·50	30·69
2. Linseed cake	88·50	4·75	6·50	2·00	1·40	106·40	44·80	31·36
3. Decorticated cotton cake	90·00	6·60	7·00	3·10	2·00	147·84	69·44	44·80
4. Palm-nut cake	91·00	2·50	3·60	1·20	0·50	56·00	26·88	11·20
5. Undecorticated cotton cake	87·00	3·75	6·00	2·00	2·00	84·00	44·80	44·80
6. Cocoa-nut cake	90·00	3·40	6·00	1·40	2·00	76·16	31·36	44·80
7. Rape cake	89·00	4·90	7·50	2·50	1·50	109·76	56·00	33·60
8. Peas	85·00	3·60	2·50	0·85	0·96	80·64	19·04	21·50
9. Beans	85·00	4·00	3·00	1·10	1·30	89·60	24·64	29·12
10. Lentils	88·00	4·20	4·00	0·75	0·70	94·08	16·80	15·68
11. Tares (seed)	84·00	4·20	2·50	0·80	0·60	94·08	17·92	17·92
12. Maize	88·00	1·70	1·40	0·60	0·37	38·08	13·44	8·29
13. Wheat	85·00	1·80	1·70	0·85	0·53	40·32	19·04	11·87
14. Malt	94·00	1·70	2·50	0·80	0·50	38·08	17·92	11·20
15. Barley	84·00	1·65	2·20	0·75	0·55	36·96	16·80	12·32
16. Oats	86·00	2·00	2·80	0·60	0·50	44·80	13·44	11·20
17. Rice meal[1]	90·00	1·90	7·50	(0·60)	(0·37)	42·56	(13·44)	(8·29)
18. Locust beans[1]	85·00	1·20	2·50	...	...	26·88		
19. Malt coombs	90·00	3·90	8·00	2·00	2·00	87·36	44·80	44·80
20. Fine pollard	86·00	2·45	5·50	2·90	1·46	54·88	64·96	32·70
21. Coarse pollard	86·00	2·50	6·40	3·50	1·50	56·00	78·40	33·60
22. Bran	86·00	2·50	6·50	3·60	1·45	56·00	80·64	32·48
23. Clover hay	83·00	2·40	7·00	0·57	1·50	53·76	12·77	33·60
24. Meadow hay	84·00	1·50	6·50	0·40	1·60	33·60	8·96	35·84
25. Pea straw	82·50	1·00	5·50	0·35	1·00	22·40	7·84	22·40
26. Oat straw	83·00	0·50	5·50	0·24	1·00	11·20	5·38	22·40
27. Wheat straw	84·00	0·45	5·00	0·24	0·80	10·08	5·38	17·92
28. Barley straw	85·00	0·40	4·50	0·18	1·00	8·96	4·03	22·40
29. Bean straw	82·50	0·90	5·00	0·30	1·00	20·16	6·72	22·40
30. Potatoes	25·00	0·25	1·00	0·15	0·55	5·60	3·36	12·32
31. Carrots	14·00	0·20	0·90	0·09	0·28	4·48	2·02	6·27
32. Parsnips	16·00	0·22	1·00	0·19	0·36	4·93	4·26	8·06
33. Mangel wurzels	12·50	0·22	1·00	0·07	0·40	4·93	1·57	8·96
34. Swedish turnips	11·00	0·25	0·60	0·06	0·22	5·60	1·34	4·93
35. Yellow turnips[1]	9·00	0·20	0·65	(0·06)	(0·22)	4·48	(1·34)	(4·93)
36. White turnips	8·00	0·18	0·68	0·05	0·30	4·03	1·12	6·72

[1] In the case of neither rice meal, locust beans, nor yellow turnips, have records of ash analyses been found. For rice meal the same percentages of phosphoric acid and potash as in maize, and for yellow turnips the same as in swedes, are provisionally adopted; but where the results are assumed they are given in parentheses. For locust beans no figure has been assumed, and the columns are left blank.

Table XXXI., revised by Lawes and Gilbert in 1897, shows the method and the results of the calculation of the *total* or *original manure value* of the different foods, adopting as a basis their composition as given in Table XXX. When the table was constructed in 1875 the values per ℔ of the important manurial ingredients were taken as ammonia, 8d.; phosphoric acid, 2½d.; potash, 2d. At the revision of the table in 1885 these were altered to 6d., 3d., and 2½d. respectively. At the subsequent revision in 1897 the fluctuations in prices which had then taken place rendered necessary a further modification to 4d. per ℔ for ammonia, 2d. per ℔ for phosphoric acid, and 1½d. per ℔ for potash, these being the lowest of all. They determine the figures given in the last column of the table, representing the total manure value per ton of food consumed. The sum of £2, 11s. 11d., for example, denoting the manure value of one ton of linseed cake consumed, is the aggregate of £2, 1s. 2d. for nitrogen; 6s. 11d. for phosphoric acid, and 3s. 10d. for potash.

This table is of interest alike to the stockfeeder and to the valuer, and it will repay closer study. The first column shows the estimated amounts of each food required to give one part of fattening increase in live weight of oxen or sheep; and the second column shows the amounts of such increase that would, accordingly, be acquired by the consumption of one ton of each food. Some such estimate must necessarily be made before it is possible to calculate how much of the manure constituents of the food are carried off by the animal increase, and consequently how much remain for manure. It must not, however, be concluded that, by the consumption by oxen or sheep of one ton of any one of the different foods *used alone*, the amount of fattening increase given in the second column of the table would be produced,—that, for example, a ton of linseed cake, if so given, would yield 373 ℔, a ton of oat straw 124 ℔, or a ton of mangels 23 ℔ of increase. What is meant is that, when any one of the foods is given in the judicious amount and in admixture with other foods which experience shows to be beneficial, it may be estimated that one ton of the food so consumed will, approximately, contribute the amount of increase in live weight stated.

Taking into consideration the difficulties attending the experimental determination of these values, it is claimed that they are the best that existing knowledge renders it possible to arrive at. Nevertheless, it is pretty certain

TABLE XXXI.—*Showing the Data, the Method, and the Results of the Estimation of the Original Manure Value of Cattle Foods after Consumption.*

Nos.	Description of Food.	Fattening Increase in live weight (Oxen or Sheep).		NITROGEN.							PHOSPHORIC ACID.						POTASH.						Total or original Manure Value per Ton of Food consumed.	Nos.
				In Food.		In fattening Increase (at 1·27 per cent.)		In Manure.			In Food.		In fattening Increase (at 0·86 per cent.)		In Manure.		In Food.		In fattening Increase (at 0·11 per cent.)		In Manure.			
		Food to 1 Increase.	Increase per Ton of Food.	Per Cent.	Per Ton.	From 1 Ton of Food.	Per Cent. of total consumed.	Total remaining for Manure.	Nitrogen equal Ammonia.	Value of Ammonia at 4d. per lb.	Per Cent.	Per Ton.	From 1 Ton of Food.	Per Cent. of total consumed.	Total remaining for Manure.	Value at 2d. per lb.	Per Cent.	Per Ton.	From 1 Ton of Food.	Per Cent. of total consumed.	Total remaining for Manure.	Value at 1½d. per lb.		
			℔	P. c.	℔	℔	P. c.	℔	℔	£ s. d.	P. c.	℔	℔	P. c.	℔	s. d.	P. c.	℔	℔	P. c.	℔	s. d.	£ s. d.	
1	Linseed	5·0	448·0	3·60	80·64	5·69	7·06	74·95	91·0	1 10 4	1·54	34·50	3·85	11·16	30·65	5 1	1·37	30·69	0·49	1·60	30·20	3 9	1 19 2	1
2	Linseed cake	6·0	373·3	4·75	106·40	4·74	4·45	101·66	123·4	2 1 2	2·00	44·80	6·21	7·17	41·59	6 11	1·40	31·36	0·41	1·31	30·95	3 10	2 11 11	2
3	Decorticated cotton cake	6·5	344·6	6·60	147·84	4·38	2·96	143·46	174·2	2 18 1	3·10	69·44	2·96	4·26	66·46	11 1	2·00	44·80	0·38	0·85	44·42	5 7	3 14 9	3
4	Palm-nut cake	7·0	320·0	2·50	56·00	4·06	7·25	51·94	63·1	1 1 0	1·20	26·88	2·75	10·23	24·13	4 0	0·50	11·20	0·35	3·13	10·65	1 4	1 6 4	4
5	Undecorticated cotton cake	8·0	280·0	3·75	84·00	3·56	4·24	80·44	97·7	1 12 7	2·00	44·80	2·41	5·38	42·39	7 1	2·00	44·80	0·31	0·69	44·49	5 7	2 5 3	5
6	Cocoa-nut cake	8·0	280·0	3·40	76·16	3·56	4·67	72·60	88·2	1 9 5	1·40	31·36	2·41	7·66	28·95	4 10	2·00	44·80	0·31	0·69	44·49	5 7	1 19 10	6
7	Rape cake	(10)	(224)	4·90	109·76	2·84	2·59	106·92	129·8	2 3 3	2·50	56·00	1·93	3·45	54·07	9 0	1·50	33·60	0·25	0·74	33·35	4 2	2 16 5	7
8	Peas	7·0	320·0	3·60	80·64	4·06	5·03	76·58	93·0	1 11 0	0·85	19·04	2·75	14·44	16·29	2 9	0·96	21·50	0·35	1·63	21·15	2 8	1 16 5	8
9	Beans	7·0	320·0	4·00	89·60	4·06	4·53	85·54	103·9	1 14 8	1·10	24·64	2·75	11·16	21·89	3 8	1·30	29·12	0·35	1·20	28·77	3 7	2 1 11	9
10	Lentils	7·0	320·0	4·20	94·08	4·06	4·32	90·02	109·3	1 16 5	0·75	16·80	2·75	16·37	14·05	2 4	0·70	15·68	0·35	2·23	15·33	1 11	2 0 8	10
11	Tares (seed)	7·0	320·0	4·20	94·08	4·06	4·32	90·02	109·3	1 16 5	0·80	17·92	2·75	15·35	15·17	2 6	0·80	17·92	0·35	1·95	17·57	2 2	2 1 1	11
12	Maize	7·2	311·1	1·70	38·08	3·95	10·37	34·13	41·4	0 13 10	0·60	13·44	2·68	19·94	10·76	1 9	0·37	8·29	0·34	4·10	7·95	1 0	0 16 7	12
13	Wheat	7·2	311·1	1·80	40·32	3·95	9·80	36·37	44·2	0 14 9	0·85	19·04	2·66	14·08	16·38	2 9	0·53	11·87	0·34	2·86	11·53	1 5	0 18 11	13
14	Malt	7·0	320·0	1·70	38·08	4·06	10·66	34·02	41·3	0 13 9	0·80	17·92	2·75	15·35	15·17	2 6	0·50	11·20	0·35	3·13	10·85	1 4	0 17 7	14
15	Barley	7·2	311·1	1·65	36·96	3·95	10·69	33·01	40·1	0 13 4	0·75	16·80	2·66	15·95	14·12	2 4	0·55	12·32	0·34	2·76	11·98	1 6	0 17 2	15
16	Oats	7·5	298·7	2·00	44·80	3·79	8·46	41·01	49·8	0 16 7	0·60	13·44	2·57	19·12	10·87	1 10	0·50	11·20	0·33	2·94	10·87	1 4	0 19 9	16
17	Rice meal	7·5	298·7	1·90	42·56	3·79	8·91	38·77	47·1	0 15 8	(0·60)	(13·44)	2·57	(19·12)	(10·87)	(1 10)	(0·37)	(8·29)	0·33	(4·00)	(7·96)	(1 0)	(0 18 6)	17
18	Locust beans	9·0	248·9	1·20	26·88	3·16	11·76	23·72	28·8	0 9 7	...	...	2·14	...	...	...	...	...	0·27	...	...	...	...	18
19	Malt coombs	8·0	280·0	3·90	87·36	3·56	4·08	83·80	101·8	1 13 11	2·00	44·80	2·41	5·38	42·39	7 1	2·00	44·80	0·31	0·69	44·49	5 7	2 6 7	19
20	Fine pollard	7·5	298·7	2·45	54·88	3·79	6·91	51·09	62·0	1 0 8	2·90	64·96	2·57	3·96	62·39	10 5	1·46	32·70	0·33	1·01	32·37	4 1	1 15 2	20
21	Coarse pollard	8·0	280·0	2·50	56·00	3·56	6·35	52·44	63·7	1 1 3	3·50	78·40	2·41	3·07	75·99	12 8	1·50	33·60	0·31	0·92	33·29	4 2	1 18 1	21
22	Bran	9·0	248·9	2·50	56·00	3·16	5·64	52·84	64·2	1 1 5	3·60	80·64	2·14	2·65	78·50	13 1	1·45	32·48	0·27	0·83	32·21	4 0	1 18 6	22
23	Clover hay	14·0	160·0	2·40	53·76	2·03	3·78	51·73	62·8	1 0 11	0·57	12·77	1·38	10·81	11·39	1 11	1·50	33·60	0·16	0·54	33·42	4 2	1 7 0	23
24	Meadow hay	15·0	149·3	1·50	33·60	1·90	5·65	31·70	38·5	0 12 10	0·40	8·96	1·28	14·28	7·68	1 3	1·60	35·84	0·16	0·45	35·68	4 6	0 18 7	24
25	Pea straw	16·0	140·0	1·00	22·40	1·78	7·95	20·62	25·0	0 8 4	0·35	7·84	1·20	15·31	6·64	1 1	1·00	22·40	0·15	0·67	22·25	2 9	0 12 2	25
26	Oat straw	18·0	124·4	0·50	11·20	1·58	14·11	9·62	11·7	0 3 11	0·24	5·38	1·07	19·89	4·31	0 9	1·00	22·40	0·14	0·63	22·26	2 9	0 7 5	26
27	Wheat straw	21·0	106·7	0·45	10·08	1·36	13·49	8·72	10·6	0 3 6	0·24	5·38	0·92	17·10	4·46	0 9	0·80	17·92	0·12	0·67	17·80	2 3	0 6 6	27
28	Barley straw	23·0	97·4	0·40	8·96	1·24	13·84	7·72	9·4	0 3 2	0·18	4·03	0·84	20·84	3·19	0 6	1·00	22·40	0·11	0·49	22·29	2 9	0 6 5	28
29	Bean straw	22·0	101·8	0·90	20·16	1·29	6·39	18·87	22·9	0 7 8	0·30	6·72	0·88	13·10	5·84	1 0	1·00	22·40	0·11	0·49	22·29	2 9	0 11 5	29
30	Potatoes	60·0	37·3	0·25	5·60	0·47	8·39	5·13	6·2	0 2 1	0·15	3·36	0·32	9·52	3·04	0 6	0·55	12·32	0·04	0·32	12·28	1 6	0 4 1	30
31	Carrots	85·7	26·1	0·20	4·48	0·33	7·37	4·15	5·0	0 1 8	0·09	2·02	0·22	10·89	1·80	0 4	0·28	6·27	0·03	0·48	6·24	0 9	0 2 9	31
32	Parsnips	75·0	29·9	0·22	4·93	0·38	7·71	4·55	5·5	0 1 10	0·19	4·26	0·26	6·10	4·00	0 8	0·36	8·06	0·03	0·37	8·03	1 0	0 3 6	32
33	Mangel wurzels	96·0	23·3	0·22	4·93	0·30	6·09	4·63	5·6	0 1 10	0·07	1·57	0·20	12·74	1·37	0 3	0·40	8·96	0·03	0·34	8·93	1 1	0 3 2	33
34	Swedish turnips	109·1	20·5	0·25	5·60	0·26	4·64	5·34	6·5	0 2 2	0·06	1·34	0·18	13·46	1·16	0 2	0·22	4·93	0·02	0·41	4·91	0 7	0 2 11	34
35	Yellow turnips	133·3	16·8	0·20	4·48	0·21	4·69	4·27	5·2	0 1 9	(0·06)	(1·34)	0·14	(10·78)	(1·20)	(0 2)	(0·22)	(4·93)	0·02	(0·34)	(4·91)	(0 7)	(0 2 6)	35
36	White turnips	150·0	14·9	0·18	4·03	0·19	4·71	3·84	4·7	0 1 7	0·05	1·12	0·13	11·61	0·99	0 2	0·30	6·72	0·02	0·30	6·70	0 10	0 2 7	36

NOTE.—Assumed results are given in parentheses.

that the amounts of increase assumed to be produced are higher than those usually obtained. The amount estimated to be yielded by linseed cake, for example, is certainly higher than would be obtained when, as is sometimes the case, it is given in such excessive amount that much is voided by the animals undigested. On the other hand, the amounts of the different foods estimated to be required to give one part of increase are doubtless higher than would be so required, if as large a proportion of the constituents were digested and utilised as has been shown to be digestible in the German experiments on that subject. In those experiments the animals were for the most part kept on mere sustenance food, so that they would digest the maximum proportion of the constituents they received. In the case of fattening, however, especially with early maturity, the conditions are very different. The animal receives a greater or less excess of food, and not only voids proportionally more undigested, but may transform more than is fully utilized. It is, nevertheless, economy to give an excess within certain limits. The apparent waste is, in fact, more than counterbalanced. Thus, in the first place, the manure value of the not-utilized food still remains intact; but the real source of the economy is in the shortening of the time of feeding, and so, at the cost of some excess of food, saving the amount that would be expended in the mere sustenance of the animal in feeding for a longer period.

The next section of the table, headed "Nitrogen," and comprising seven columns, relates to the amount and to the distribution of the foods. There are given the amounts of nitrogen per cent. and per ton as in Table XXX.; the actual amount estimated to be contained in the increase in live weight of the animal consuming one ton of the food, and the percentage of the total nitrogen consumed which is so retained in the increase; the amount of the nitrogen of the food remaining for manure, the amount of ammonia to which it corresponds, and its money value, reckoned at 4d. per ℔. Throughout the calculations it is assumed that only fattening increase is produced, and that this will contain 8 per cent. of nitrogenous substance, corresponding to 1·27 per cent. of nitrogen in the increase. It will be seen that, according to the figures, the only food in the list of which a ton is estimated to contribute more than 5 ℔ of nitrogen to the fattening increase is linseed, and that in the case of none of the cakes, or of the leguminous seeds, will 1 ton contribute 5 ℔ of nitrogen to the increase, whilst the amount is in several cases under 4 ℔. A ton of the cereal grains, or of their products (and locust beans), generally contributes under 4 ℔; a ton of hay or straw less than half as much; and a ton of roots very much less still. To put it in another way: of the total nitrogen consumed in the foods rich in that substance, such as the cakes and the leguminous seeds, there is generally less than 5 per cent. retained in the fattening increase in live weight. The cereal grains, on the other hand, which are much less rich in nitrogen, contribute a much larger proportion of their total amount to the increase; indeed, generally about 10 per cent. of it. The gramineous straws contribute a higher proportion still, whilst roots (mangels and turnips) lose by feeding on an average only about 5 or 6 per cent. of their nitrogen. Hence, when fattening increase only is produced, the proportion of the nitrogen of the food which is retained by the animal, and so lost to the manure, is very small in the case of the richer foods, but more in that of the poorer ones; but even with them it seldom exceeds 10 per cent., excepting with the straws. It may be assumed, however, that when the foods are consumed by store animals, about twice as much of the nitrogen of the food is retained by the animal, and so lost to the manure. And when, as is more and more the case with early maturity, the increase comprises a larger proportion of growth than in mere fattening, the amount of the nitrogen of the food which will be lost to the manure will be between that given in the table and twice as much.

The third section of the table relates to the phosphoric acid, and there are given for each food, as in the case of the nitrogen, the amounts of it per cent. and per ton of the foods; the amount estimated to be retained in the increase; the amount remaining for manure, and the money value of this at 2d. per ℔. It will be seen that there is only about two-thirds as much phosphoric acid as of nitrogen retained in a given weight of fattening increase; but, owing to the very generally less, and sometimes much less, amount of it in the foods, a greater proportion of that consumed is retained in the animal, and a less proportion remains for manure. It should be added that, in the case of store animals and of animals still growing, the amount of phosphoric acid retained in a given weight of increase will be very much greater than in mere fattening; indeed, in mere store increase it may, as in the case of the nitrogen, be nearly twice as great.

Of potash, the table shows that a given weight of fattening increase retains only about one-eighth as much as it does of phosphoric acid; and the percentage of the whole in the food which is lost to the manure is generally very small. In its case, as in that of the nitrogen and phosphoric acid, the amount retained in mere store increase will be nearly twice as much as in mere fattening increase, but the total quantity retained is still very small. The potash remaining for manure is valued at 1½d. per ℔.

The last column of the table shows the total manure value of a ton of each of the foods after consumption, reckoning the nitrogen, the phosphoric acid, and the potash at the prices above named, which are those at which they could, at the time (1897-98), be purchased in artificial manures. The reductions in the prices of ammonia, phosphoric acid, and potash, now adopted, bring all the estimates of total or original manure value almost exactly one-third lower than those given in 1885. Thus the total value of a ton of linseed cake consumed, which in 1885 was reckoned at £3, 18s. 6d., was taken in 1897-98 at £2, 11s. 11d.; that of a ton of oats was reduced from £1, 9s. 10d. to 19s. 9d.; and that of other foods in the same proportion.

Unexhausted Manure Value of Cattle Foods.—A much more complicated problem than the estimation of the *total* or *original manure value* of cattle foods is that of estimating the *unexhausted manure value* of the different foods, or what may be called their *compensation value*, after they have been used for a series of years by the outgoing tenant, and he has realized a certain portion of the manure value in his increased crops. In the light of experimental and other evidence, Lawes and Gilbert fixed upon a scale of reduction, starting from the total or original manure value, as estimated in Table XXXI. The method so arrived at is to deduct one-half of the original manure value of the food used the last year, and one-third of the remainder each year to the eighth, in the case of all the more concentrated foods, and of the roots; whilst, for the hays and straws, which contain larger amounts of indigestible matter, and the constituents of which will be more slowly available for crops, two-thirds of the original manure value is deducted for the last year, and only one-fifth from year to year to the eighth year. The results of the estimates of *compensation value* so made are given in Table XXXII. The first column shows the *total* or *original manure value* of each food. The second column shows the allowance

TABLE XXXII.—*Plan and Results of Estimations of the Compensation Value of Unexhausted Manure, starting from the Original Manure Value, that is, the Value deducting the constituents of increase in (Fattening) Live Weight only.*

Foods.	Original Manure Value, deducting increase in Live Weight only.	Compensation Value of Unexhausted Manure.								
		Last Year.	Second Year.	Third Year.	Fourth Year.	Fifth Year.	Sixth Year.	Seventh Year.	Eighth Year.	Total.
Deduct One-half of Original Manure Value the Last Year, and One-third from Year to Year.										
One Ton.	£ s. d.	£ s. d.	£ s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	£ s. d.
1. Linseed	1 19 2	0 19 7	0 13 1	8 9	5 10	3 11	2 7	1 9	1 2	2 16 6
2. Linseed cake	2 11 11	1 6 0	0 17 4	11 7	7 9	5 2	3 5	2 3	1 6	3 15 0
3. Decorticated cotton cake	3 14 9	1 17 4	1 4 11	16 7	11 1	7 5	4 11	3 3	2 2	5 7 8
4. Palm-nut cake	1 6 4	0 13 2	0 8 9	5 10	3 11	2 7	1 9	1 2	6 9	1 17 11
5. Undecorticated cotton cake	2 5 3	1 2 7	0 15 1	10 1	6 9	4 6	3 0	2 0	1 4	3 5 4
6. Cocoa-nut cake	1 19 10	0 19 11	0 13 3	6 10	5 11	3 11	2 7	1 9	1 2	2 17 4
7. Rape cake	2 16 5	1 8 3	0 18 16	12 7	8 5	5 7	3 9	2 6	1 8	4 1 7
8. Peas	1 16 5	0 18 3	0 12 2	8 1	5 5	3 7	2 5	1 7	1 1	2 12 7
9. Beans	2 1 11	1 0 11	0 13 11	9 3	6 2	4 1	2 9	1 10	1 3	3 0 2
10. Lentils	2 0 8	1 0 4	0 13 7	9 1	6 1	4 1	2 9	1 10	1 3	2 19 0
11. Tares (seed)	2 1 1	1 0 7	0 13 9	9 2	6 1	4 1	2 9	1 10	1 3	2 19 6
12. Maize	0 16 7	0 3 4	0 5 7	3 9	2 6	1 8	1 1	0 9	0 6	1 4 2
13. Wheat	0 18 11	0 9 6	6 6 4	4 3	2 10	1 11	1 3	0 10	0 7	1 7 6
14. Malt	0 17 7	0 8 10	0 5 11	3 11	2 7	1 9	1 2	0 9	0 6	1 5 5
15. Barley	0 17 2	0 8 7	0 5 9	3 16	2 7	1 9	1 2	0 9	0 6	1 4 11
16. Oats	0 19 9	6 9 11	0 6 7	4 5	2 11	1 11	1 3	0 10	0 7	1 8 5
17. Rice meal	(0 18 6)	(0 9 3)	(0 6 2)	(4 1)	(2 9)	(1 10)	(1 3)	(0 10)	(0 7)	(1 6 9)
18. Locust beans	...	...	...	...	...	...	...	...	...	...
19. Malt coombs	2 6 7	1 3 3	0 15 6	10 4	6 11	4 7	3 1	2 1	1 5	3 7 2
20. Fine pollard	1 15 2	0 17 7	0 11 9	7 10	5 3	3 6	2 4	1 7	1 1	2 10 11
21. Coarse pollard	1 18 1	0 19 1	0 12 9	8 6	5 6	3 9	2 6	1 8	1 1	2 15 0
22. Bran	1 18 6	0 19 3	0 12 10	8 7	5 9	3 10	2 7	1 9	1 2	2 15 9
Deduct Two-thirds of Original Manure Value the Last Year, and One-fifth from Year to Year.										
One Ton.										
23. Clover hay	1 7 0	0 9 0	0 7 2	5 9	4 7	3 8	2 11	2 4	1 10	1 17 3
24. Meadow hay	0 18 7	0 6 2	0 4 11	3 11	3 2	2 6	2 0	1 7	1 3	1 5 6
25. Pea straw	0 12 2	0 4 1	0 3 8	2 7	2 1	1 6	1 4	1 1	0 10	0 16 11
26. Oat straw	0 7 5	0 2 6	0 2 0	1 7	1 3	1 0	0 10	0 6	0 6	0 10 4
27. Wheat straw	0 6 6	0 2 2	0 1 9	1 5	1 2	0 11	0 9	0 7	0 6	0 9 3
28. Barley straw	0 6 5	0 2 2	0 1 9	1 5	1 2	0 11	0 9	0 7	0 6	6 9 3
29. Bean straw	0 11 5	0 3 16	0 3 1	2 6	2 0	1 7	1 3	1 6	0 10	0 16 1
Deduct One-half of Original Manure Value the Last Year, and One-third from Year to Year.										
Ten Tons.										
36. Potatoes	2 0 16	1 0 5	0 13 7	9 1	6 1	4 1	2 9	1 10	1 3	2 19 1
31. Carrots	1 7 6	0 13 9	0 9 2	6 1	4 1	2 9	1 16	1 3	0 10	1 19 9
32. Parsnips	1 15 0	0 17 6	0 11 6	7 9	5 2	3 5	2 3	1 6	1 0	2 10 3
33. Mangel wurzels	1 11 8	0 15 10	0 10 7	7 1	4 9	3 2	2 1	1 5	0 11	2 5 10
34. Swedish turnips	1 9 2	0 14 7	0 9 9	6 6	4 4	2 11	1 11	1 8	0 10	2 2 1
35. Yellow turnips	(1 5 0)	(0 12 6)	(0 6 4)	(5 7)	(3 9)	(2 6)	(1 8)	(1 1)	(0 9)	(1 16 2)
36. White turnips	1 5 10	0 12 11	0 6 7	5 9	3 10	2 7	1 9	1 2	0 9	1 7 4

for the last year, and the succeeding seven columns that for each succeeding year to the eighth. The last column gives the *total compensation value* for the eight years' consumption. It may seem at first sight that a deduction of 50 per cent. from the original manure value of the food used in the last year is large. Allowance has to be made, however, for all losses to which the manure may be subject, which may be considerable, especially if much of the food is consumed in the yards; and it has to be borne in mind that the money paid for compensation will not yield its full return for a long time. Only half the original manure value would, therefore, be allowed if the food were only used one year; and all scales of allowance arranged by farmers' clubs assume the consumption for more than one year. Nevertheless, if the food is used for eight years, or more, it will be seen that the total allowance considerably exceeds the original manure value of one year's consumption—the allowance made for the accumulation bringing it up to from one and a third to one and a half as much as the original manure value.

In order to test the applicability of the scale of compensation proposed, the case may be considered of a Norfolk or Lincolnshire farm under the ordinary four-course rotation, with meat and grain only sold, and the roots fed partly on the land and partly in the yards. Let it be assumed, further, that the land is thoroughly clean, and that the farm is in every respect in good order when given up. The essential basis of the system of estimate and valuation of the unexhausted residue adopted is the assumption of gradual accumulation within the soil, and of slow recovery from it. Suppose then that linseed cake had been used annually for eight years, at the average rate of one ton over eight acres each year, or of one ton per acre in eight years. Each acre would thus on the average receive, either in farmyard manure or directly by the feeding with roots or clover on the land, the manure from the consumption of one ton of linseed cake in eight years, or at the average rate of one-eighth of a ton, or 2½ cwt., per acre per annum.

The first column of Table XXXII. shows that the *total or original manure value* of one ton of linseed cake consumed—that is, the value deducting only the constituents stored up in the animal—is estimated to be £2, 11s. 11d. The subsequent columns of the same table show the estimated *compensation value* of the *unexhausted residue* from one ton consumed (that is, after the tenant has realized the benefit of the increase of his crops) to be, if used each year for eight years, as given in the first column of the following statement, the second column showing the amount per acre per annum:—

	Compensation Allowances for One Ton of Linseed Cake consumed.					
	Per annum, Eight Years.			Per acre, in Eight Years.		
	£	s.	d.	£	s.	d.
Last year . . .	1	6	0	0	3	3
2nd ,, . . .	0	17	4	0	2	2
3rd ,, . . .	0	11	7	0	1	5
4th ,, . . .	0	7	9	0	1	0
5th ,, . . .	0	5	2	0	0	8
6th ,, . . .	0	3	5	0	0	5
7th ,, . . .	0	2	3	0	0	3
8th ,, . . .	0	1	6	0	0	2
Total . .	3	15	0	0	9	4

Thus, according to the first column of figures, the value of the unexhausted manure residue from the consumption of one ton of linseed cake annually for eight years would be £3, 15s., or nearly 45 per cent. more than the original manure value of one year's consumption. Or, as the second column shows, the allowance would be at the rate of 9s. 4d. per acre over the whole farm. Whether such an allowance would be too much or too little under the conditions supposed is a question for consideration. These conditions are: a light-land farm, upon which the manure from purchased food is an essential element of profitable cultivation; that meat and grain alone are sold; and that the farm is given up in a satisfactory state in every respect. Also that, on the average, each acre received during the last eight years the manure derived from the consumption of one ton of linseed cake. The question between the two parties concerned is, whether the outgoing tenant would receive sufficient remuneration for his unexhausted manure; and, on the other hand, whether the landowner, or the incoming tenant, would pay more than will be recovered in increase of crops. An allowance of 9s. 4d. per acre on a farm of 400 acres would amount to £186, 13s. 4d., which is a large sum to pay; and it is certain that the recovery of the amount would only be gradual. It is well known that both time and money are required to get land into condition, and here is land already in condition.

Although in the foregoing tables the estimates of the manure values of food-stuffs are made in accordance with the prices of ammonia, phosphoric acid, and potash at the time (1898), it is evident that the results may require further revision as the value of manure constituents in the market changes, and perhaps also in other ways, as knowledge advances and experience is gained.[1]

IMPLEMENTS AND MACHINERY.

Agricultural machinery is dealt with elsewhere. As, however, it is the custom of the Royal Agricultural Society of England to invite competitions at its annual shows in specified classes of implements, an enumeration of these will indicate the character of the appliances which were thus brought into prominence during the closing quarter of the 19th century. These trials taking place, with few intermissions, year after year serve to direct the public mind to the development, which is continually in progress, of the mechanical aids to agriculture. The awards here summarized are quite distinct from those of silver medals which are given by the Society in the case of articles possessing sufficient merit, which are entered as "new implements for agricultural or estate purposes."

In 1875, at Taunton, special prizes were awarded for one-horse and two-horse mowing machines, hay-making machines, horse rakes (self-acting and not self-acting), guards to the drums of threshing-machines, and combined guards and feeders to the drums of threshing machines. In 1876, at Birmingham, the competitions were of self-delivery reapers, one-horse reapers, and combined mowers and reapers without self-delivery. In 1878, at Bristol, the special awards were all for dairy appliances—milk-can for conveying milk long distances, churn for milk, churn for cream, butter-worker for large dairies, butter-worker for small dairies, cheese tub, curd knife, curd mill, cheese-turning apparatus, automatic means of preventing rising of cream, milk-cooler, and cooling vat. A gold medal was awarded for a harvester and self-binder (M'Cormick's). In 1879, at Kilburn, the competition was of railway waggons to convey perishable goods long distances at low temperatures. In 1880, at Carlisle, and in 1881, at Derby, the special awards were for broadside steam diggers and string sheaf-binders respectively. In 1882, at Reading, a gold medal was given for a cream separator for horse power, whilst a prize of 100 guineas offered for the most efficient and most economical method of drying hay or corn crops artificially, either before or after being stacked, was not awarded. In 1883, at York, a prize of £50 was given for a butter dairy suitable for not more than twenty cows. In 1884, at Shrewsbury, a prize of £100 was awarded for a sheaf-binding reaper, and one of £50 for a similar machine. In 1885, at Preston, the competitions were concerned with two-horse, three-horse, and four-horse whipple-trees, and packages for conveying fresh butter by rail. In 1886, at Norwich, a prize of £25 was awarded for a thatch-making machine. In 1887, at Newcastle-on-Tyne, a prize of £200 went to a compound portable agricultural engine, one of £100 to a simple portable agricultural engine, and lesser prizes to a weighing machine for horses and cattle, a weighing machine for sheep and pigs, potato-raisers, and one-man power cream separators. In 1888, at Nottingham, hay and straw presses for steam power, horse power, and hand power were the subjects of competition. In 1889, at Windsor, prizes were awarded for a fruit and vegetable evaporator, a paring and coring machine, a dairy thermometer, parcel post butter-boxes to carry different weights, and a vessel to contain preserved butter. In 1890, at Plymouth, competitions took place of light portable engines (*a*) using solid fuel (*b*) using liquid or gaseous fuel, grist mills for use on a farm, disintegrators, and cider-making plant for use on a farm. In 1891, at Doncaster, special prizes were given for combined portable threshing and finishing machines, and cream separators (hand and power). In 1892, at Warwick, the competitions related to ploughs—single furrow (*a*) for light land, (*b*) for strong land, (*c*) for press drill and broadcast sowing; two-furrow; three-furrow; digging (*a*) for light land (*b*) for heavy land; and one-way ploughs. In 1893, at Chester, self-binding harvesters and sheep-shearing machines (power) were the appliances respectively in competition. In 1894, at Cambridge, the awards were for fixed and portable oil engines, potato-spraying and tree-spraying machines, sheep-dipping apparatus, and churns. In 1895, at Darlington, the competitions were confined to hay-making machines and clover-making machines. In 1896, at

---

[1] For a fuller discussion of the subject the reader should consult Lawes and Gilbert's paper in the *Journal of the Royal Agricultural Society*, 1897. In the course of a letter written early in 1901, Sir J. Henry Gilbert referred to the question as to how the manure from store stock should be valued. The loss to the manure is more in the case of the feeding of lean or store stock than in that of fattening animals, but is much less than in the case of milk production. Assuming the increase from the consumption of a given food by store stock removed twice as much of the constituents valuable as manure as when used for fattening, the result would approximately be that, in the case of any of the high-nitrogen foods, Nos. 1 to 11 in Table XXXII., 5 per cent. would be sufficient to deduct from the original manure value before applying the scale according to the "class of farm" as defined below; and that in the case of the lower-nitrogen foods, Nos. 12 to 17, a deduction of 10 per cent. would be sufficient. With reference to the valuation of the manure constituents when the foods are consumed by fattening pigs, the conclusion arrived at is that, although there are characteristic differences between the amount and proportion of the various foods consumed by oxen and sheep on the one hand, and by pigs on the other, yet there would not be such material difference in the case of the same description of food consumed respectively by oxen, sheep, and pigs, as to render it desirable to make any distinction in estimating the manure value of the same food thus consumed.

In actual practice it has been found convenient, in applying the estimates of manure value, to modify the compensation according to the class of farm, thus: (1) where the consumption is on farms that have been well managed, with the yard accommodation for the proper conservation of manure good, or where the feeding-stuffs have been fed on land left clean, and the management has been generally good and judicious; (2) where such conditions are not so good and meritorious; (3) where such conditions are bad.

Leicester, prizes were awarded after trial to potato-planting machines, potato-raising machines, and butter-drying machines. In 1897, at Manchester, special awards were made for fruit baskets and milk-testers. In 1898, at Birmingham, a prize of £100 was given for a self-moving vehicle for light loads, £100 and £50 for self-moving vehicles for heavy loads, and £10 for safety feeder to chaff-cutter, in accordance with the Chaff-cutting Machines (Accidents) Act, 1897. In 1899, at Maidstone, special prizes were offered for machines for washing hops with liquid insecticides, cream separators (power and hand), machines for the evaporation of fruit and vegetables, and packages for the carriage of (*a*) soft fruit (*b*) hard fruit. In 1900, at York, the competitions were concerned with horse-power cultivators, self-moving steam diggers, milking machines, and sheep-shearing machines (power and hand). In 1901, at Cardiff, competition was invited in portable oil engines, agricultural locomotive oil engines, and small ice-making plant suitable for a dairy.

The progress of steam cultivation has not justified the hopes that were once entertained concerning this method of working implements in the field. It was about the year 1870 that its advantages first came into prominent notice. At that time owing to labour disputes the supply of hands was short and horses were dear. The wet seasons that set in at the end of the 'seventies led to so much hindrance in the work on the land that the aid of steam was further called for, and it seemed probable that there would be a lessened demand for horse power. It was found, however, that the steam work was done with less care than had been bestowed upon the horse tillage, and the result was that steam came to be regarded as an auxiliary to horse labour rather than as a substitute for it. In this capacity it is capable of rendering most valuable assistance, for it can be utilized in moving extensive areas of land in a very short time. Accordingly, when a few days occur early in the season favourable to the working of the land, much of it can be got into a forward condition, whilst horses are set free for the lighter operations. The crops can then be sown in due time, which in wet years, and with the usual teams of horses kept on a farm, is not always practicable. Much advantage arises from the steam-working of bastard fallows in summer, and after harvest a considerable amount of autumn cultivation can be done by steam power, thus materially lightening the work in the succeeding spring. On farms of moderate size it is usual to hire steam tackle as required, the outlay involved in the purchase of a set being justifiable only in the case of estates or of very big farms where, when not engaged in ploughing, or in cultivating, or in other work upon the land, the steam-engine may be employed in threshing, chaff-cutting, sawing, and many similar operations which require power. The labour question again became acute in 1900, when owing to the scarcity of hands and the high rate of wages, self-binding harvesters were resorted to in England for the ingathering of the corn crops to a greater extent than ever before. For the same reason potato-planting and potato-lifting machines were also in greater requisition. (W. FR.)

II. THE UNITED STATES.

Covering as it does the breadth of the North American continent, with 3,000,000 square miles of land surface, not including Alaska and the islands, of which 700,000,000 acres are in farms and 400,000,000 in actual cultivation, representing every variety of soil and all the climatic life zones of the world, except the extreme boreal and the hottest tropical, the United States affords an important subject of study in respect of agriculture. Its cotton, wheat, and meat are large factors in all markets, and its many other agricultural products are distributed throughout the civilized world. To the student the equipment and methods of agriculture in the United States form as interesting a subject of examination as do its resources and production. In quantity, distribution, and inter-relation of heat and moisture—the chief factors in agricultural production—the United States is greatly blessed. We find in this vast territory all the agricultural belts mapped by the biologist, producing all varieties of cereals, fruits, and breeds of live stock. All kinds of soils, adapted to different crops, are spread out at all altitudes from 8000 feet down to sea-level. The country is equally fortunate in the character of its farming class. There is no peasant class, but the agricultural population is made up of the same people who form the professional and mercantile classes. The negroes, who supply the farm labour in the Southern States, are by nature admirably suited to these pursuits. The inventive skill of the American has had almost as full scope upon the farm as in the shop, with the result that the equipment and methods used are well adapted to the conditions.

Statistics.

The story of the vast and varied agriculture of the United States can be most briefly, and, perhaps, best told in the figures of the census and other Government reports. Unless some other source is mentioned, the statistics in this article are taken from the eleventh (1890) census (crops of 1889), or the reports of the Department of Agriculture, whose annual estimates are based upon the latest figures.

Farms.

As a result of the great supply of available land the number of farms in the United States increased between 1850 and 1890 215 per cent., or from 1,450,000 to 4,565,000; their total acreage increased 112 per cent., or from 294,000,000 to 623,000,000 acres; their improved acreage increased 216 per cent., or from 113,000,000 to 358,000,000 acres; and their unimproved acreage 47 per cent., or from 181,000,000 to 266,000,000 acres. The following table (No. I.) exhibits the increases of number of farms, total and improved acreage, by decades:—

TABLE I.—*Percentage of Increase of Number and Acreage of Farms by Census Decades.*

The United States.	Number of Farms.	Acreage.	
		Total.	Improved.
1850 to 1860 . . .	41·1	38·7	44·3
1860 to 1870 . . .	30·1	0·1	15·8
1870 to 1880 . . .	50·7	31·5	50·7
1880 to 1890 . . .	13·9	16·2	25·6
1850 to 1890 . . .	215·0	112·3	216·4

The largest percentage of increase of improved land was 50·7, from 1870 to 1880; the lowest was in the decade 1860 to 1870, the period of the Civil war, and was 15·8. There was a marked slackening in the increase both of the number of farms and of improved land in the last decade, when public lands adapted to agriculture had approached more nearly the point of complete occupation. The chief cause of this wonderful development of agriculture is the large area of cheap public lands which has been available for immigrants and natives alike. Up to 1897, 529,000 homestead entries had been made and finally settled for 70,397,000 acres of Government land under the Homestead Act of 20th May 1862, while the number of entries, both final and pending, covered 102,280,000 acres. Between 1875 and 1897 the public and Indian lands sold for cash and under homestead and timber culture laws, as well as those allotted by scrip, granted to the colleges of agriculture and mechanic arts and other institutions, and by military bounty land warrants, and selected by States and railroad corporations, covered 300,000,000 acres. In addition to this, the States and railroad corporations sold a large amount of land to farmers of which we have no accurate record. This vast territory, greater in extent than

Germany and France combined, was added to the farms of the country in twenty-two years. In many cases railroad building has made the settlement of the public lands possible for the first time, and the building of branch lines, by providing means for transporting products to market, has greatly facilitated the acquisition of other lands. The mileage of railways increased 245 per cent. between 1870 and 1896. The interesting fact is that this increase corresponds geographically to the increase in farms.

The agricultural statistics do not include any farm of less than three acres unless it produced at least $500 worth of products the preceding year. The census of 1890 showed that the average size of farms was 137 acres, or three acres more than in 1880 and 66 acres less than in 1850. Within a certain limit the average area of farms is determined by the financial ability of the owners. In this day of farm machines, an owner must have a certain amount of land in order to afford the necessary equipment for cultivating it successfully. This fact appears to have stopped the further subdivision of farms and to have started a movement towards their consolidation. As will be seen from the following table (No. II.), the average farm, which steadily diminished in size from 1850 to 1880, actually increased slightly between 1880 and 1890, owing chiefly to the enlargement of the wheat farms of the west.

TABLE II.—*Average Acreage of Farms and Improved Land therein by Census Years.*

The United States.	Average Number of Acres.	
	Improved.	Whole Farm.
1850	78	203
1860	80	199
1870	71	155
1880	70	133
1890	78	137

The figures for the average farm areas of improved land represent more truly the actual economic condition. Thus it is instructive to notice that the number of acres under cultivation (improved land) on each farm was on the average the same—78 acres—at the end of the forty-years period as at its beginning. The existence of available surplus land has its influence; but the increasing use of improved machines and tools, and the construction of convenient railroads, appear to be the chief causes for the enlargement of farms.

In farms cultivated by owners there was an increase between 1880 and 1890 of 285,422, or 9·56 per cent.; in farms rented for money, of 132,302, or 41 per cent.; and in farms rented for a share of the products, of 138,010, or 19·65 per cent. In 1890, 71·6 of all the farms were cultivated by their owners, as against 74·4 per cent. in 1880. From 1880 to 1890 the farm tenancy grew from 25·6 to 28·4 per cent., an increase of 2·8 per cent. The steady drift towards farm tenancy of late is believed to be injurious to production; but it is impossible to prove this, so great has been the aggregate increase in products.

Agricultural occupations.

The number of persons engaged in agriculture as a business in 1890 was 8,395,634, or 37 per cent. of all persons in gainful occupations. It is interesting to note that 678,000 of these were women. This is an increase of nearly 1,000,000 persons over 1880, or 12·6 per cent. Thus, if the farm family is the same size as that of the remainder of the population—it is probably slightly larger—the agricultural population would be 37 per cent. of the whole. Statisticians usually put it at 40 per cent., and this is probably more nearly correct.

TABLE III.—*Number of Persons of Ten Years of Age and over in the Different Agricultural Pursuits in* 1890.

Occupation.	Total Persons.
Dairymen and women	17,895
Farmers and farm superintendents	5,281,557
Farm labourers	3,004,061
Gardeners, nurserymen, and viticulturists	72,601
Other pursuits	19,520
Total	8,395,634

The increase in farm tenancy, and especially the diminished demand for labour relative to products, due to the growing use of machinery, reduced the number of agricultural labourers who work for wages from 49 per cent. of all agricultural workers in 1870 to 43·6 in 1880 and 35·8 in 1890. The wages paid farm labourers, as ascertained by the Department of Agriculture, are rather low compared with the average wages of labour, but not lower than the wages of other unskilled labour. The average monthly wage of the agricultural labourer, without board, was $19.50 in 1870, $16.42 in 1880, $18.33 in 1890, and $17.70 in 1895. These wages are good as compared with those earned in Continental countries.

Value of farms and products.

The figures for farm capital and the value of agricultural products are so vast that it is extremely difficult to put them in form to be grasped intelligently. The farm capital of the United States reported by the census of 1890 reached $15,500,000,000, the main classes being, in round numbers:—Land, fences, and buildings, $13,000,000,000; machines and implements, $500,000,000; live stock, $2,000,000,000. The products of the farms in the census year, 1889, were valued at $2,500,000,000. Between 1850 and 1890 the aggregate farm capital increased 303 per cent.; the value of annual products increased between 1870 and 1890, 15·5 per cent. The greatest increase of farm capital was between 1850 and 1860, 101 per cent.; the next was the decade 1880 to 1890, when the increase was 29 per cent. From 1870 to 1880 the value of farm products increased 4 per cent.; from 1880 to 1890, 11 per cent. It is noteworthy that "the value of capital increased in a much greater degree than the value of products."

In order to put the facts about the crops grown in the United States in a form that may be readily understood, Mr Holmes of the Department of Agriculture has computed the number of railroad freight cars of fifteen tons' capacity required to haul the crops of 1897 and what their length in trains would be. He tells us that to haul the hay crop 4,017,933 cars would be needed, and the length of the train would be 25,112 miles, or more than long enough to encircle the earth at the equator; for the corn crop there must be 3,540,257 cars, making a train 22,127 miles long; the wheat crop would take 1,060,000 cars, with a total length of 6625 miles, or farther than from New York to Cape Horn; for the oat crop a train of 772,098 cars, extending 4826 miles, or from New York to the Congo River; the potato crop would take a train of 327,354 cars, and 2046 miles long, which would extend from New York to Utah; the cotton crop would take a train as long as from New York to Chicago, and the barley crop one that would reach from Washington, D.C., to Atlanta, Ga.

The growth of farm area and of capital invested in agriculture was followed by a proportionate increase in the principal crops. Between 1880 and 1890 the area devoted to each crop increased as follows:—Indian corn (maize), 15·6 per cent.; rye, 17·9 per cent.; oats, 75·4 per cent.; barley, 61·2 per cent.; cotton, 39·3 per cent.; sugar-cane, 20·7 per cent.; hay, 72·9 per cent.; and tobacco, 8·8 per cent.; while the area in wheat decreased 5·2 per cent.; buckwheat, 1·3 per cent.; and rice, 7·4 per cent. The following table (No. IV.), arranged by Holmes, gives the increase or decrease in five principal crops for each decade from 1840, when the first census of agricultural products was taken, down to 1890:—

TABLE IV.—*Percentage of Increase (+) or Decrease (−) of Production of Farm Crops, by Time Periods.*

The United States.	Indian Corn.	Wheat.	Oats.	Cotton.	Tobacco.
1840 to 1850	+ 56·6	+18·5	+19·1	+ 56·2	− 6·9
1850 to 1860	+ 41·7	+72·3	+17·8	+118·2	+117·4
1860 to 1870	− 9·6	+66·2	+63·4	− 44·1	− 39·5
1870 to 1880	+130·6	+59·7	+44·6	+ 91·1	+ 79·9
1880 to 1890	+ 21·0	+ 1·9	+98·4	+ 29·6	+ 3·3
1840 to 1890	+462·2	+452·2	+557·6	+372·7	+122·8

The distinguishing feature of the period 1870 to 1880 is the rate of increase of corn, wheat, cotton, and tobacco. Since 1870 the production of nearly all of the farm crops increased more rapidly than the population, the most absolute proof of the substantial prosperity of the people. The increase in population for the fifty years from 1840 to 1890 was 267 per cent.; from 1870 to 1880, 30 per cent.; from 1880 to 1890, 25 per cent.; but the food and other supplies have far exceeded the demands of even this great population.

Until the use of more and cheaper motors becomes possible, farm animals must increase with farming operations. "At the census of 1890 there were 14,969,467 horses on farms, 2,295,532 mules and asses, 1,117,494 working oxen, 16,511,950 milch cows, 33,734,128 other cattle, 57,409,583 swine, and 35,935,364 sheep, not including spring lambs; and in the census year the wool clip amounted to 165,449,239 pounds, not including pulled wool and wool clipped on ranges, which were sufficient, according to the estimates of the department, to make the entire wool clip for the census year 276,000,000 pounds. In forty years, from the census of 1850 to that of 1890, the number of horses on farms increased 245·2 per cent.; mules and asses, 310·4 per cent.; milch cows, 158·6 per cent.; other cattle, 248 per cent.; swine, 89·1 per cent.; sheep, not including spring lambs, 65·4 per cent., and the farm wool clip increased 215 per cent.; but working oxen decreased 34·3 per cent." (*Holmes*).

The following tables give the most important facts with regard to the cereal production of the United States between 1870 and 1899 (Tables V. and VI.):—

TABLE V.—*Average Yield and Value of Cereal Crops in the United States, by Periods of Years, 1870 to 1899.*

The United States.	Corn.			Wheat.			Oats.		
	Average Farm Price per Bushel.	Average Yield per Acre.	Average Value per Acre.	Average Farm Price per Bushel.	Average Yield per Acre.	Average Value per Acre.	Average Farm Price per Bushel.	Average Yield per Acre.	Average Value per Acre.
	Dollars.	Bushels.	Dollars.	Dollars.	Bushels.	Dollars.	Dollars.	Bushels.	Dollars.
1870 to 1880 .	0·426	27·1	11·54	1·05	12·4	13·00	0·353	28·4	10·03
1880 to 1889 .	·393	24·1	9·46	·827	12·1	9·98	·309	26·6	8·22
1890 to 1896 .	·355	24·1	8·55	·656	13·0	8·54	·286	25·2	7·21
1897 . .	...	23·8	6·27	...	13·4	10·86	...	27·2	5·75
1898 . .	...	24·8	7·10	...	15·3	8·92	...	28·4	7·23
1899 . .	...	25·3	...	...	12·3	...	...	30·2	...

TABLE VI.—*Average Yield and Value of Cereal Crops in the United States, by Periods of Years, 1870 to 1896.*

The United States.	Barley.			Rye.			Buckwheat.		
	Average Farm Price per Bushel.	Average Yield per Acre.	Average Value per Acre.	Average Farm Price per Bushel.	Average Yield per Acre.	Average Value per Acre.	Average Farm Price per Bushel.	Average Yield per Acre.	Average Value per Acre.
	Dollars.	Bushels.	Dollars.	Dollars.	Bushels.	Dollars.	Dollars.	Bushels.	Dollars.
1870 to 1880 .	0·738	22·1	16·34	0·701	14·1	9·92	0·715	17·7	12·65
1880 to 1889 .	·589	21·7	12·79	·622	11·9	7·39	·642	12·6	6·24
1890 to 1896 .	·374	22·8	8·52	·467	13·6	6·35	·490	17·4	8·51

The average farm price of wheat declined, as is shown in the above tables, from $1.05 per bushel for the decade 1870 to 1880 to 65·8 cents for the period 1890 to 1896. The farm prices of the other cereals declined less during the twenty-seven years. Corn declined from an average farm price of 42·6 cents per bushel for 1870-80 to 35·5 cents in 1890 to 1896. The farm value of wheat per acre ranged from $13 in 1870-80 to $8.54 in 1890-1896; it then advanced to $10.86 in 1897, and fell to $8.92 in 1898. In farm value per acre corn averaged $11.54 in the decade 1870 to 1880, and $8.55 in 1890-96. The other cereals declined in the same manner in value per acre. The average production per acre shows nothing conclusive with regard to the fertility of the soil of the country. The expansion of the crop area usually causes a lowering of the average yield per acre by distributing the culture, fertilizers, &c., over more surface. Likewise the contraction of crop area will usually increase the average yield per acre of the entire country. The average bushels of wheat per acre was 12·4 in the decade 1870 to 1880, and 13 in the period 1890 to 1896; of corn, 27·1 in 1870 to 1880, and 24·1 in 1880 to 1896 continuously. Oats fell off from 28·4 to 25·2 bushels per acre from the first to the last period.

The agricultural returns for 1890 to 1899 may be taken as an illustration of the cereal production of the United States. The figures for wheat, oats, and Indian corn are presented in Tables Nos. VII., VIII., and IX.

The acreage and production of wheat have steadily increased; the total farm value of the crop has averaged $330,000,000 a year for the last ten years. The acreage in Indian corn, the great American crop, reached its highest in 1899, 82,000,000 acres, and its production its highest figure in 1896, 2,284,000,000 bushels.

Producing as the United States does so much more than its people can consume, its exports form a large percentage of some of the crops, as Table X., from the *Year Book* of the Department of Agriculture for 1897, shows.

The average percentage of wheat crop exported annually

TABLE VII.—*Acreage, Production, Value, Prices, and Exports of Wheat in the United States in* 1890 *to* 1899.

Year.	Acreage.	Average Yield per Acre.	Production.	Average Farm Price per Bushel, 1st Dec.	Farm Value, 1st Dec.	Chicago Cash Price per Bushel, No. 2.				Domestic Exports, including Flour, Fiscal Years beginning 1st July.
						December.		May of following Year.		
						Low.	High.	Low.	High.	
	Acres.	Bushels.	Bushels.	Cents.	Dollars.	Cents.	Cents.	Cents.	Cents.	Bushels.
1890 .	36,087,154	11·1	399,262,000	83·8	334,773,678	87½	92¾	98⅞	108	106,181,616
1891 .	39,916,897	15·6	611,780,000	83·9	513,472,711	89⅝	93½	80	85⅝	225,665,612
1892 .	38,554,460	13·4	515,949,000	62·4	322,111,881	69½	73	68¼	76¼	191,912,635
1893 .	34,629,418	11·4	396,131,725	53·8	213,171,381	59⅛	64½	52⅛	60⅛	164,283,129
1894 .	34,882,436	13·2	460,267,416	49·1	225,902,025	52¾	63⅝	60¾	75⅝	144,812,718
1895 .	34,047,332	13·7	467,102,947	50·9	237,938,998	53⅜	64¾	57⅛	67⅝	126,443,968
1896 .	34,618,646	12·4	427,684,348	72·6	310,602,539	74⅝	93⅛	88½	97⅞	145,124,972
1897 .	39,465,066	13·4	530,149,168	80·8	428,547,121	92	109	117	185	217,806,005
1898 .	44,055,278	15·3	675,148,705	58·2	392,770,320	62¾	70	68⅜	79¼	222,694,920
1899 .	44,592,516	12·3	547,303,846	58·4	319,545,259	64	89½	...	...	...

TABLE VIII.—*Acreage, Production, Value, Prices, and Exports of Oats in the United States in* 1890 *to* 1899.

Year.	Acreage.	Average Yield per Acre.	Production.	Average Farm Price per Bushel, 1st Dec.	Farm Value, 1st Dec.	Chicago Cash Price per Bushel, No. 2.				Domestic Exports, including Oatmeal, Fiscal Years beginning 1st July.	Imports during Fiscal Years beginning 1st July.[1]
						December.		May of following Year.			
						Low.	High.	Low.	High.		
	Acres.	Bushels.	Bushels.	Cents.	Dollars.	Cents.	Cents.	Cents.	Cents.	Bushels.	Bushels.
1890	26,431,369	19·8	523,621,000	42·4	222,048,486	39⅞	43⅞	45½	54	1,382,636	41,848
1891	25,581,861	28·9	738,394,000	31·5	232,312,267	31⅛	33⅝	28⅛	33⅛	10,586,644	47,782
1892	27,063,835	24·4	661,035,000	31·7	209,253,611	25⅝	31¼	28¾	32½	2,700,793	49,433
1893	27,273,033	23·4	638,854,850	29·4	187,576,092	27⅛	29⅛	32⅛	36	6,290,229	31,759
1894	27,023,553	24·5	662,036,928	32·4	214,816,920	28⅜	29⅝	27⅛	30⅜	1,706,824	830,817
1895	27,878,406	29·6	824,443,537	19·9	163,655,068	16⅝	17⅛	16	19⅝	15,156,618	66,602
1896	27,565,985	25·7	707,346,404	18·7	132,485,033	16⅛	18⅜	16⅞	18¾	37,725,083	893,908
1897	25,730,375	27·2	698,767,809	21·2	147,974,719	21	23⅞	26	32	76,680,307	25,093
1898	25,777,110	28·4	730,906,643	25·5	186,405,364	26	27¾	24	27½	33,534,264	28,098
1899	26,341,380	30·2	796,177,713	24·9	198,167,975	22½	23	...	...	...	...

[1] In years 1866 and 1884 to 1899, inclusive, oatmeal is included.

TABLE IX.—*Acreage, Production, Value, Prices, and Exports of Corn in the United States in* 1890 *to* 1899.

Year.	Acreage.	Average Yield per Acre.	Production.	Average Farm Price per Bushel, 1st Dec.	Farm Value, 1st Dec.	Chicago Cash Price per Bushel, No. 2.				Domestic Exports, including Corn Meal, Fiscal Years beginning 1st July.
						December.		May of following Year.		
						Low.	High.	Low.	High.	
	Acres.	Bushels.	Bushels.	Cents.	Dollars.	Cents.	Cents.	Cents.	Cents.	Bushels.
1890 .	71,970,763	20·7	1,489,970,000	50·6	754,433,451	47¾	53	55	69½	32,041,529
1891 .	76,204,515	27·0	2,060,154,000	40·6	836,439,228	39⅝	59	40⅝	100	78,602,285
1892 .	70,626,658	23·1	1,628,464,000	39·4	642,146,630	40	42⅞	39⅛	44⅛	47,121,894
1893 .	72,036,465	22·5	1,619,496,131	36·5	591,625,627	34¼	36⅛	36¾	38⅛	66,489,529
1894 .	62,582,269	19·4	1,212,770,052	45·7	554,719,162	44¾	47⅛	47¾	55⅛	28,585,405
1895 .	82,075,830	26·2	2,151,166,580	25·3	544,985,534	25	26¾	27⅛	29⅛	101,100,375
1896 .	81,027,156	28·2	2,283,875,165	21·5	491,006,967	22⅛	23¾	23	25⅛	178,817,417
1897 .	80,095,051	23·8	1,902,967,933	26·3	501,072,952	25	27⅛	32⅜	37	212,055,543
1898 .	77,721,781	24·8	1,924,184,660	28·7	552,023,428	33⅛	38	32⅛	34⅜	177,255,046
1899 .	82,108,587	25·3	2,078,143,933	30·3	629,210,110	30	31⅛	...	...	...

TABLE X.—*Percentage of Crops Exported. Averages for Period* 1878 *to* 1896.

Crop.	Annual Average.		
	1878-82.	1888-92.	1894-96.
Wheat . . .	27·84	17·68	15·96
Corn . . .	4·82	6·49	5·39
Rye . . .	10·30	...	12·21
Oats . . .	·67	·80	2·22
Barley . . .	1·55	...	12·98
Potatoes . .	·37	...	·30
Tobacco . . .	55·64	...	67·42
Cotton . . .	72·60	66·79	73·60

from 1894 to 1896 was 16; of corn, 5·4; of rye, 12·2; of barley, 13; of tobacco, 67·4; of cotton, 73·6. Large portions of some of these crops, like corn and oats, are exported in the form of animals and animal products (meats, lard, hides, &c.). The hay crop is almost entirely used in this way, and the tendency is to convert more and more of these crops into these higher-priced products. Still, the time is far distant when domestic consumption will come anywhere near overtaking domestic production, especially of wheat and the other cereals. The certain extension of acreage with the growth of demand and price, the increased use of agricultural implements, and the improvement of methods will be sure to keep up a large surplus for export for long years to come. The Department of Agriculture has found that for home use there is required per caput 5·5 bushels of wheat, 28·6 bushels of corn, and 10·7 bushels of oats, the computations being made from the figures for population, production, and exports for 1888 to 1892. The following number of acres in these crops are required, therefore, to supply the home demand:—0·43 of 1 acre in wheat, 1·15 acre in corn, and 0·43 acre in oats per head of the population. If we take the year 1890 as an illustration, this gave a surplus area in wheat of 11,264,478 acres, of 2,648,404 acres in corn, and of 238,162 acres in oats.

Number and value of animals per farm.

There were 4,008,907 farms in the United States in 1880, and in 1890 there were 4,564,641, an increase of 13·9 per cent. In 1880 the average number of horses to the farm was 2·8, and in 1890, 3·1. In 1880 there was an average of 0·4 mule per farm in the United States, and in 1890 the number had increased to 0·5. There were on the average three milch cows on each farm in 1880, and in 1890 the number had increased to 3·5. The number of other cattle per farm was 5·3 in 1880, and in 1890 it was 8·1. The average number of sheep fell from 10·2 in 1880 to 9·7 in 1890. There was a corresponding decrease in value. The number of swine rose from 8·5 in 1880 to 11·3 in 1890. There were on the average farm in the United States in 1880, 30·2 animals, whose total value was $393, and in 1890 there were 36·2 animals valued at $529, an increase in numbers of 19·9 per cent., more than keeping pace with the increase in number of farms, which was 13·9 per cent.; and in value the increase was $136, or 34·6 per cent.[1]

Table XI. shows the average number and value of animals on farms in the United States in 1880 and 1890, with the percentage of increase or decrease during the decade.

In 1880 there were 23 horses to each 100 of population in the United States. The number increased to 25 in 1893, and declined to 21 in 1896. For the decade 1880-90 the average was 21½, and for the period 1890-98 the average was 23. The average value of horses per 100 of population for the ten-years period 1880-90 was $1462, and for the period 1890-98 $1300. In 1880 there were 3 mules for each 100 of population, and after increasing to 4 in 1894 it fell to 3 in 1899. The value of mules per 100 of population increased from $214 in 1880 to $296 in 1889, and declined steadily to $150 in 1898. Since the war with Spain there has been a marked increase in value, which still continues. Between 1880 and 1890 there were about 25 milch cows for every 100 of population. After 1890 the number increased to 26, and in 1896 fell off to 23. The average value of cows per 100 of population increased steadily from $565 in 1890 to $780 in 1884, but decreased to $520 in 1898. The latest reports indicate a marked increase again. The number of sheep in proportion to population increased from 82 per 100 in 1880 to 93 in 1884, from which there was a steady decrease to 53 in 1898. The values increased from $182 per 100 of population in 1880 to $234 in 1883, from which there was a downward movement, reaching the lowest point, $92, in 1896. The number of swine per 100 of population commenced with 69 in 1880 and reached their highest point, 85, in 1882, then decreased to 75 in 1888, and to 63 in 1898. The values started at $295 in 1880, went up to $550 per 100 in 1883, and then declined to $270 in 1898. The total value of all farm animals per 100 of population increased from $3185 in 1880 to the highest point, $4454, in 1884, from which there was a steady decrease to $2300 in 1898. The following tables (XII. and XIII.) give the number, total value, and average price of farm animals in 1880, 1890, and 1900:—

Table XI.—*Average Number and Value of Animals per Farm in the United States in 1880 and 1890, and Percentage of Increase or Decrease.*

Animals.	1880.		1890.		Percentage of increase (+) or decrease (−).	
	Number.	Value.	Number.	Value.	Number.	Value.
Horses .	2·8	$153	3·1	$214	+10·7	+39·9
Mules .	0·4	26	0·5	40	+25·0	+53·8
Milch cows .	3·0	70	3·5	77	+16·7	+10·0
Other cattle	5·3	85	8·1	123	+52·8	+44·7
Sheep. .	10·2	23	9·7	22	− 4·9	− 4·3
Swine. .	8·5	36	11·3	53	+32·9	+47·2
Total .	30·2	393	36·2	529	+19·9	+34·6

Table XII.—*Number and Value of Farm Animals in the United States,* 1880 *to* 1900.

January 1.	Horses.		Mules.		Milch Cows.	
	Number.	Value.	Number.	Value.	Number.	Value.
1880	11,201,800	$613,296,611	1,729,500	$105,948,319	12,027,000	$279,899,420
1890	14,213,837	978,516,562	2,331,027	182,394,099	15,952,883	352,152,133
1900	13,537,524	603,969,442	2,086,027	111,717,092	16,292,360	514,812,106

January 1.	Other Cattle.		Sheep.		Swine.		Total Value of Farm Animals.
	Number.	Value.	Number.	Value.	Number.	Value.	
1880	21,231,000	$341,761,154	40,765,900	$90,230,537	34,034,100	$145,781,515	$1,576,917,556
1890	36,849,024	560,625,137	44,336,072	100,659,761	51,602,780	243,418,336	2,418,766,028
1900	27,610,054	689,486,260	41,883,065	122,665,913	...	...	a2,042,650,818

a Exclusive of swine.

Table XIII.—*Average Value of Farm Animals in the United States on 1st January,* 1880 *to* 1900.

Year.	Horses.	Mules.	Milch Cows.	Other Cattle.	Sheep.	Swine.
1880 . .	$54.75	$61.26	$23.27	$16.10	$2.21	$1.28
1890 . .	68.84	78.25	22.14	15.21	2.27	4.72
1900 . .	44.61	53.56	31.60	24.97	2.93	...

Since the Civil War the number of horses has increased and prices have gradually declined. In 1893 the number of horses reached the highest figure, 16,206,802, an increase of over 5,005,002, or 44·6 per cent. over the number in 1880. The average farm price of horses increased from $54.75 in 1880 to $74.64 in 1884, after which there was an uninterrupted decrease to $31.51 in 1896. The extension of street-car lines, and the substitution of cable and electric power for that of horses, and the use of bicycles have been factors in decreasing the demand for these animals. The record for mules has been parallel to that for horses.

The returns for milch cows show an increase throughout the period 1880-99 in every year, with the exception of

---

[1] Condensed from Report of the Division of Statistics of the U.S. Dept. of Agriculture, 1899.

1895 to 1899. For the first ten years the numbers increased 32·6 per cent., and from 1890 to 1899, ·2 per cent. The total value of milch cows increased each year until 1884, then decreased until 1891, with a gradual increase until the end of the period. The farm price of milch cows rose from $23.27 in 1880 to $31.37 in 1884, then fell to $21.40 in 1892, after which there was a steady increase to $31.60 in 1899.

No marked changes in the numbers of sheep have taken place. During the period 1880-90 there was an increase in numbers amounting to about 8·8 per cent. Since 1893 there has been a rather steady decrease, with fluctuations amounting to a marked depression after 1894. This industry is very susceptible to adverse influences, and felt keenly the depression in the price of wool. The increase commenced again in 1898, and numbers have gone up for two years.

The numbers and values of swine constantly fluctuate with the movement and value of the corn crops. The returns for 1890 showed a numerical increase of 51·6 per cent. over those of 1880; then followed a steady decrease in numbers down to 1897, since which time there has been a slight increase. The movement in values was similar to that in numbers. From $4.28 in 1880, the average farm price of hogs increased steadily to $6.75 in 1883. The lowest figure, $4.15, was reached in 1891, and after numerous fluctuations it became $4.40 in 1899.

The total value of farm animals had a steady increase from 1880 to 1890, with slight variations in 1885 and 1886. Following 1890 there has been a steady decrease down to the present time, with the exception of slight increases in 1892 and 1893. In 1880 the total value of farm animals in the United States was $1,576,917,556. In 1890 it had increased to $2,418,766,028, or 53·4 per cent. In 1896 the value had decreased to $1,727,926,084, or 28·6 per cent., from the 1890 values, and an increase of 9·6 per cent. over those of 1880.

The exports of live stock and its products have increased enormously in recent years, both in quantity and value. This is especially true of the exportation of beef, cattle, and meat products. The exports of cattle increased from 182,750 in 1880 to 331,720 in 1895, or 81½ per cent., and values from $13,340,000 in 1880 to $30,600,000 in 1895, an increase of 129 per cent. The average value of cattle exported has increased from $19 in 1870 to $73 in 1880 and $92 in 1895. It must be said, however, that only the best and heaviest cattle are exported, which command a much higher price than the average of the country.

The total value of farm animals exported from the United States has fluctuated greatly. On the whole, however, the value has increased from $16,000,000 in round numbers, in 1880, to nearly $36,000,000 in 1895, or 125 per cent. The following table (No. XIV.), compiled from statistics of the United States Treasury Department, shows, by years, the number and value of each kind of live animal exported between 1880 and 1895, inclusive.

Table XIV.—*Number and Value of Farm Animals exported from the United States, by years,* 1880 *to* 1895.

Year ending 30th June.	Horses.		Mules.		Cattle.		Sheep.		Swine.		Total Value.
	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.	
1880	3,060	$675,139	5,198	$532,362	182,756	$13,344,195	209,137	$892,647	83,434	$421,089	$15,865,432
1881	2,523	390,243	3,207	353,924	185,707	14,304,103	170,919	762,932	77,456	572,138	16,383,340
1882	2,248	470,183	2,632	320,130	108,110	7,800,227	139,676	603,778	36,368	509,651	9,703,969
1883	2,800	475,806	4,237	486,560	104,444	8,341,431	337,251	1,154,856	16,129	272,516	10,731,169
1884	2,721	424,317	3,742	490,809	190,518	17,855,495	273,874	850,146	46,382	627,480	20,248,247
1885	1,947	377,692	1,028	127,580	135,890	12,906,690	234,509	512,568	55,025	579,183	14,503,713
1886	1,616	348,323	1,191	148,711	119,065	10,958,954	177,594	329,844	74,187	674,297	12,460,129
1887	1,611	351,607	1,754	214,738	106,459	9,172,136	121,701	254,725	75,383	564,753	10,557,959
1888	2,263	412,774	2,971	378,765	140,208	11,577,578	143,817	280,490	23,755	193,017	12,842,624
1889	3,748	592,469	2,980	356,333	205,786	16,616,917	128,852	366,181	45,128	356,764	18,288,664
1890	3,501	680,410	3,544	447,108	394,836	31,261,131	67,521	243,077	91,148	909,042	33,540,768
1891	3,110	784,908	2,184	278,658	374,679	30,445,249	60,947	261,109	95,654	1,146,630	32,916,554
1892	3,226	611,188	1,965	238,591	394,607	35,099,095	46,960	161,105	31,963	364,081	36,474,060
1893	2,967	718,607	1,634	210,278	287,094	26,032,428	37,260	126,394	27,375	397,162	27,484,869
1894	5,246	1,108,995	2,063	240,961	359,278	33,461,922	132,370	832,763	1,553	14,753	35,659,394
1895	19,984	2,209,298	2,515	186,452	331,722	30,603,796	405,748	2,630,686	7,130	72,424	35,702,656

The exports of meat products of all kinds, including canned meats and oleomargarine, are subject to considerable fluctuation, both in quantity and value, rendering it impossible to describe them in a few words. The exports of beef products, which amounted to 241,000,000 pounds, in round numbers, in 1880, increased, with fluctuations, to a maximum of 507,000,000 pounds in 1891, since which time they have decreased to 345,000,000 pounds in 1895. The values of beef products exported from the country fell from $26,000,000 in 1880 to a minimum of $15,000,000 in 1887, and reached a maximum value of $35,000,000 in 1891. The value of beef products exported in 1895 was $27,000,000, in round numbers. The exports of hog products have varied in a similar manner from 1,230,000,000 pounds in 1880 down to a minimum of 715,000,000 pounds in 1884, reaching 1,160,000,000 pounds in 1890. The exports for 1895 were 1,090,000,000 pounds. Values have varied in a similar manner from a maximum of $105,000,000 in 1881 down to $57,000,000 in 1886, and back up to $93,000,000 in 1894. The exports of mutton show a marked decrease, both in quantity and values. Starting from a maximum of 3,380,000 pounds in 1881, they have decreased, with many fluctuations, to 101,000 pounds in 1892, but increased suddenly to 2,200,000 pounds in 1894, since which time they have fallen off again. The values of these exports fell from $258,000 in 1881 to $9003 in 1892, and increased to $174,000 in 1894. The exports of oleomargarine were first regularly reported in 1884, and have increased, on the whole, from 40,000,000 pounds in 1881 to 127,000,000 pounds in 1894, and in values from $4,800,000 in 1884 to $12,400,000 in 1894. The total value of exported meat products, including canned goods and oleomargarine, has increased from $111,000,000 in 1880 to $134,000,000 in 1894 and $125,400,000 in 1895. The increase for the entire period was about $14,480,000, or 13 per cent.

The facts with regard to the production, imports, exports, and consumption of wool in the United States are presented in Table XV., compiled from estimates from the Department of Agriculture and the reports of the bureau of statistics of the Treasury Department. The production of wool shows an increase, with fluctuations, from 232,500,000 pounds in 1880 to 309,748,000 pounds in 1895, an increase of 33 per cent. The imports show numerous fluctuations, both in quantities and values. The total value of the imports of wool in 1895 was $25,556,421. The exports of domestic wool show an enormous increase, with numerous violent fluctuations, especially in recent years. Starting with 191,551 pounds in 1880, valued at $71,987, these exports increased in 1895 to 4,279,109 pounds, valued at $484,463, an increase of 2000 per cent. for quantity and 570 per cent. for value. The exports of foreign wool also show numerous fluctuations. Their lowest value was in 1884—$343,456, and their highest in 1881—$991,407. The consumption of wool in the United States has increased from 356,791,676 pounds in 1880 to 509,159,716 pounds in 1895, an increase of nearly 43 per cent.

TABLE XV.—*Production, Imports, Exports, and Consumption of Wool in the United States, by years,* 1880 *to* 1895.

Year ending 30th June.	Production.	Imports.		Exports of Domestic.		Exports of Foreign.		Total Exports.		Retained for Consumption.
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.	Pounds.	Dollars.	Pounds.	Dollars.	Pounds.	Dollars.	Pounds.	Dollars.	Pounds.
1880	232,500,000	128,181,747	23,727,650	191,551	71,987	3,648,520	637,586	3,840,071	709,573	356,791,676
1881	240,000,000	55,964,236	9,708,966	71,455	19,217	5,507,534	991,407	5,576,989	1,010,624	290,385,247
1882	272,000,000	67,861,744	11,096,050	116,179	37,327	3,831,836	670,503	3,948,015	707,830	335,913,729
1883	290,000,000	70,575,478	10,949,331	64,474	22,114	4,010,048	664,160	4,074,517	686,274	356,500,961
1884	300,000,000	76,350,651	12,384,709	10,393	3,073	2,304,701	343,456	2,315,094	346,529	376,035,557
1885	308,000,000	70,596,170	8,879,923	88,006	16,739	3,115,339	516,019	3,203,345	532,758	375,392,825
1886	302,000,000	129,084,958	16,746,061	146,423	19,625	6,534,426	759,442	6,680,849	779,067	424,404,109
1887	285,000,000	114,038,030	16,424,479	257,940	78,002	6,728,292	824,770	6,986,232	902,772	392,051,798
1888	269,000,000	113,558,753	15,887,217	22,164	5,272	4,359,731	626,868	4,381,895	632,140	376,176,858
1889	265,000,000	126,487,729	17,974,515	141,576	23,065	3,263,094	460,560	3,404,670	483,625	388,083,059
1890	276,000,000	105,431,285	15,264,083	231,042	33,543	3,266,467	556,473	3,519,509	590,016	377,911,776
1891	285,000,000	129,303,648	18,231,372	291,922	39,423	2,638,123	361,260	2,930,045	400,683	411,373,603
1892	294,000,000	148,670,832	19,688,106	202,456	30,664	3,007,563	403,531	3,210,019	434,195	439,460,813
1893	303,153,000	172,433,838	21,064,180	91,858	14,808	4,218,637	515,470	4,310,495	530,278	471,276,343
1894	298,057,384	55,152,585	6,107,436	520,247	90,676	5,977,407	824,882	6,497,654	915,558	346,712,315
1895	309,746,000	206,033,906	25,556,421	4,279,109	484,463	2,343,081	294,100	6,622,190	778,563	509,159,716

AMERICAN WHEAT-FARMING.

That wonderful agricultural region, extending from the international line on the north to the 37th parallel, and from the Atlantic Ocean to the 100th meridian, and comprising 26 States, produces 76 per cent. of the American wheat crop. This region, which contains only 30 per cent. of the land surface of the country, but embraces 60 per cent. of its total farm area and 70 per cent. of its improved farm acreage, is the greatest cereal-producing region of the world. Besides wheat, it produces 82 per cent. of the total corn crop, 91 per cent. of the total oat crop, and 83 per cent. of the total hay crop of the United States. The methods pursued in the eastern portion of this region are similar to those used in other parts of the world; but in the north-western portion wheat-growing is carried on on a gigantic scale, and by methods almost unknown anywhere else. The best illustrations of the great or "bonanza" wheat farms, as they are called, are found along the Red River of the North, where it flows between the States of North Dakota and Minnesota.

The wheat grown in the United States is of two distinct kinds. One is the large-kernel winter wheat of the eastern States; the other is the hard spring wheat. The "blue stem" or the "Scotch-Fife" are native varieties of the latter kind grown in Minnesota and the two Dakotas. For flour-making this wheat is considered the best in the world. During the season of 1899 the product of hard spring wheat amounted to nearly 250,000,000 bushels, or two-fifths of the entire wheat product of the United States. Of this, Minnesota and the two Dakotas alone produced 200,000,000 bushels. Minnesota is the greatest wheat-producing State in the Union. Her fields in 1899 covered 5,000,000 acres, and she produced nearly 80,000,000 bushels, which is twice the entire production of all Australia, and more than that of Great Britain and Ireland put together. In Minnesota and the Dakotas the farms are devoted almost exclusively to wheat-growing. Many of them contain from 3000 to 10,000 acres. All operations on farms of this size must be carried on upon a gigantic scale. The country is a very level one, making it possible to use all kinds of machinery with great success. As there are no mountains or swamps, there is here very little waste land, and every square foot of the vast wheat fields can be made productive.

Bonanza farms.

The first characteristic of a "bonanza" wheat farm is the machinery. The smallest agricultural implement used upon them is a plough, and the largest is the elevator. A hoe or a spade is almost unknown. Between these two there are machines of all sizes adapted to the needs of the particular work. Let us assume the conditions prevailing upon a bonanza farm of 5000 acres, and briefly describe the process of wheat production from the ploughing of the land to the delivery of the grain in the final market. These great wheat farms were established upon new lands sold directly to capitalists by the railroads. The lands became the property of the railroads largely through Government grants, and they attracted capitalists, who bought them in large bodies and at low prices. The improvements made upon them consist of the cheap wooden dwellings for the managers, dormitories and dining-halls for the men, stables for the horses, and sheds and workshops for repairing machinery. Very little of the land is under fence. Since the desirable lands of the country have been occupied, the prices of these lands have advanced slowly, with the result that the big farms are being divided up into small holdings. After a generation or two, if land continues to rise in the market as it has recently, the bonanza farms will become a thing of the past. At present the best of these lands in the valley of the Red River of the North are worth from $25 to $30 an acre. The improvements upon them add about $5 an acre more. A farm is not considered a big one unless it contains from 2000 to 10,000 acres at least. There are, of course, many small farmers, owning from two to five sections (640 acres in each section), but their methods are more like those of the small farmers in the eastern United States or on the continent of Europe. It is necessary to own a large body of land in order to be able to use the machinery and methods here described. It is hard to convey a just notion of the size of these farms. They stretch away as far as the eye can reach in every direction, making it difficult even for the visitor to conceive their size. The distances across wheat fields are so great that even horseback communication is too slow. The farms are separated into divisions, and lodging-houses and dining-halls and barns are scattered over them, so as to keep the workmen and teams near the scene of their labour. The men living at one end of the farm may not see those at the other for months at a time. Even then it is necessary to take the meals to the men in the fields rather than allow them to walk or ride to the dining-halls. It is not an unusual thing for a working crew to find themselves at the dinner hour two miles from their hall.

Ploughing.

First, after burning the old straw of the previous year—which is real labour in itself, so enormous is its bulk—comes the ploughing. This begins in October. The plough used has a 16-inch share, turns two furrows, and is drawn by five horses. Each plough covers about 250 acres in a season, travelling an average of 20 miles a day. The ploughing begins in October, and continues a month or six weeks, according to the season. The ploughs are driven in "gangs" under the eye of a superintendent, who rides with them. From eight to ten of these ploughs follow each other around the vast section. If one stands a few rods ahead of them they seem to be following one another in a line; but, if one stands to the right of the "gang," one sees that the line is broken, and that the second plough is a width farther in the field than the leader, and so on for the entire number. Experience shows that it costs about 70 cents an acre to plough the land in this way. About forty men are employed upon a farm of 5000 acres during the ploughing season. The men are paid by the month, and receive about $25, including their board. They breakfast at five o'clock, take an hour for their dinner at noon—usually in the field—and have their supper at seven. At the end of the ploughing season these particular men are usually discharged. Only eight or ten are kept on a farm of this size throughout the year. The other men go back to their homes or to the factories in the cities, where they await the harvesting and threshing season. The eight or ten who remain upon the farm are employed in doing odd jobs, such as overhauling machinery, or helping the carpenter and blacksmith, or looking after the horses. The wheat region is a country of heavy snows, and of severe, dry cold; but when March comes the snows begin to melt away, and by April the ploughed land is dry enough for the harrow. The harrowing is done with 25-foot harrows, drawn by four horses, and operated by a single man. One man can harrow 60 to 75 acres a day.

Seeding.

The seeding follows immediately with four-horse press drills that cover 12 feet. The harrows and drills are worked in "gangs" as the ploughs were. Each drill will go from 20 to 25 miles a day. When the weather is good the seeding upon a 5000-acre farm will be done in twenty or twenty-five days. It is usual to seed a bushel and a peck of wheat to the acre. The wheat used for this purpose is carefully selected after the harvest of the previous year, and is thoroughly cleaned of foreign seeds. Through years of cultivation, varieties of wheat have been produced which are particularly well adapted to the soil and climate of this region. It has been found more profitable to use the native "blue stem" or "Scotch-Fife" wheat than the seed from any other country, or even from the neighbouring States. Counting the seed, wheat, and the labour, it costs about $1 an acre to harrow the ground and plant the wheat.

Labour.

When the planting is done the extra labourers are discharged again, and the regular ones are put to work on the corn, oats, and millet, which are grown to feed the horses. The men who do the most important work are all temporary labourers. They come from the cities of the east or the farms of the south. They begin with the early harvest in Oklahoma, and work northwards up the Missouri and the Red River until the season closes in Manitoba. They are not tramps, but steady, industrious men, with few bad habits and few ambitions. On well-managed farms drinking and gambling are strictly forbidden. The work is hard, and, as there are few amusements of the farm, the men spend their resting periods in sleep. Their dormitories are usually comfortably furnished, their dining-halls clean. The bonanza farmers find it good policy to feed their men well. Many a strike has occurred in the midst of the harvest because the quality or quantity of the food served was not what it ought to have been. The largest part of this food is brought from the eastern States. Some potatoes, turnips, and beans are grown upon the farms; but the corned beef, bacon, and groceries come from the cities. It is estimated that it costs 35 cents a day to feed each labourer. Farmers say that a good name in these respects enables them to get the choice of workmen, and that no money brings such sure returns as that expended in the bedrooms and upon the food.

The harvest.

The harvest labourers begin to arrive from the south about the middle of July, and by the end of this month the harvest is at its height. A farm of 5000 acres will use 75 or 100 extra men. With the men comes the new machinery in train loads. It is estimated that at least $5,000,000 worth of agricultural machines is annually sold in this region. The wheat farmers say that it does not pay to take undue care of old machinery, that more money is lost in repairing and tinkering an old machine than would pay for a new one. The result is that new machinery is bought in very large quantities, used until it is worn out or cannot be repaired without considerable work, and then left in the fields to rust. Heaps of cast-iron can be seen already upon many of the large farms. Of course a great many extra parts are bought to take the place of those which break most frequently, and some men are always kept at work repairing machines in the field. One of the big 10,000-acre farms will use up two car-loads of twine in a single harvest, enough to lay a line around the whole coast of England, Ireland, and Scotland. The harvesters vary in size according to the character of the land. Upon the rougher ground and small farms the ordinary binders are used; upon the great plains, like those of California, a great harvester is used, which has a cutting line 52 feet wide. These machines cut, thresh, and stack the grain at the rate of 1600 sacks a day, and cover an area in that time of 100 acres. These machines can only be used where the wheat ripens thoroughly standing in the field. The harvest labourer earns $10 a week everywhere in America. The bonanza farmer expects one machine to cut at least 250 acres, and three men are required for each of them. The harvest lasts from ten days to three weeks, according to the weather. Including the labour and the wear and tear, it costs about 60 cents an acre to harvest wheat.

Threshing.

The wheat is not stacked as in the eastern States and in England, but stands upright in shocks in the field. The grain cures very rapidly in the dry climate, so that by the time the wheat is all cut and shocked on one end of the division, it is ready for the thresher at the other. The shocks of wheat are hauled directly to the thresher and fed into the self-feeder. It usually takes a day and a quarter to thresh the wheat which it took a day to cut. The farmer estimates that a threshing-machine can thresh all the wheat ordinarily grown upon 2500 acres, so that a 5000-acre farmer would have at least two machines running at the same time. Time is a very important thing in threshing, since a rainfall might spoil enough grain in one night to buy several machines. The threshing season is thus a time of great pressure and of extensively active work. The wheat straw is worse than a waste product—it is a great nuisance upon the bonanza farm. A little of it is used for fuel for the engines and for bedding the stock; but the bulk of it is dragged away from the threshing machine by machinery, and left lying in great heaps until an opportunity is afforded for burning it up. This is usually done immediately before the ploughing in the autumn. The grain falls from the spout of the thresher into the box wagon, which carries it to the elevator. The elevator is placed at the railway station, and is usually owned by the bonanza farmer.

The returns.

From the time the sheaves of wheat are tumbled into the wagon until the flour reaches the hands of the cook, no hand touches the wheat that passes through the great Minneapolis mills. When the box-wagons reach the elevator the loosing of a bolt dumps the grain into the bin, where it remains until the pulling of a lever lets it into the cars. Every pound of it is weighed and accounted for, and entered upon the books, so as to show the exact product of each division of the farm. After the rush of the threshing is over the farmer studies these books carefully to see what his land is doing, and makes his plans for the next year, so as to rest or strengthen those divisions which are failing. It costs about $1.50 an acre to thresh the grain and put it into the elevator. This sum, added to the estimated cost of the other processes mentioned above, makes the total cost of growing an acre of grain about $3.80. This includes the cost of labour, seed, and wear and tear of machinery, but does not include the interest on land or plant. The taxes on land will average 25 cents an acre. The farmers estimate that the other improvements, the water-works, elevators, insurance, horse feed, &c., will make this up to $6 an acre. The best of these farms will yield 20 bushels to the acre. This makes the wheat cost 30 cents a bushel. During the last five years the average farm-selling price of wheat in the North-West has been 58 cents. An acre thus produces $11.60, making a gross profit of $5.60. Still to be provided for is the interest on the operating expenses for eighteen months, which will, at 8 per cent., be 48 cents per acre. Interest on the capital in land, improvements, and machinery, at $30 per acre, make $1.80 more, or a total interest charge of $2.28. When this is deducted from the gross profits of $5.60 prices found above, we have a net profit of $3.32 an acre, not an exorbitant one by any means. This is about 8 per cent. on the capital invested in the land, plant, and operating expenses. But we have described the conditions on one of the best bonanza farms. The average yield per acre in this region is not over 18 bushels, and the average expenses would be higher than those given.

Marketing.

Every bonanza farmer's office is connected by wire with the markets at Minneapolis, Chicago, and Buffalo. Quotations arrive hourly in the selling season, and the superintendent keeps in close touch with his agents in the wheat-pits of these and other cities. When the instrument tells him of a good price, his agent is instructed to sell immediately. The farmer on the upper waters of the Red River of the North is kept fully informed as to the drought in India, the hot winds in the Argentine, and the floods of the Danube. Any occurrences in these distant parts of the world are known to him in a surprisingly short time. The world's great wheat fields almost lie within his sight, so well does he know the conditions that prevail in them. Ten days are allowed for delivery, so that he can usually ship the wheat after it is sold. In the early days of wheat-farming the bonanza farmer often speculated, but experience has taught him that he had better leave this to the men in the cities, and content himself with the profit from the business under his eye. The great elevator centres are in Duluth, and Minneapolis, Chicago, and Buffalo. These elevators have a storage capacity of from 100,000 to 2,500,000 bushels. The new ones are built of steel, operated by steam or electricity, protected from fire by pneumatic water-pipes, and have complete machinery for drying and scouring the wheat whenever it is necessary. The elevators are provided with long spouts containing movable buckets, which can be lowered into the hold of a grain-laden vessel. The wheat is shovelled into the pathway of the huge steam shovels, which draw it up to the ends of these spouts, where the buckets seize it, and carry it upwards into the elevator, and distribute it among the various bins according to grade. A cargo of 200,000 bushels can thus be unloaded in two hours, while spouts on the other side of the elevator reload it into cars, five to ten at a time, filling a car in from five to ten minutes, or the largest canal boat in an hour. The entire work of unloading, storing, and reloading adds only one cent to the price of a bushel of wheat.

Inspecting and grading.

The great wheat-growing States like Minnesota have established systems of inspecting and grading wheat under State supervision. In Minnesota the system is carried out by the Railway and Warehouse Commission, which fixes and defines the different grades of wheat and directs the work. At present there are 18 grades recognized in this State. The first is described as "No. 1, hard spring wheat, sound, bright, and well cleaned, composed mainly of hard 'Scotch-Fife,' weighing not less than 58 ℔ to the measured bushel." The second grade is known as "No. 1, northern spring wheat, sound, and well cleaned, composed of the hard and soft varieties of spring wheat." So the varieties run—"No. 2, northern"; "No. 3, northern," &c.—down to the 18th, which is "no grade." The official inspectors examine, grade, and sample the wheat in the cars in which it is received at the great markets or elevators. The cars are sealed at the point of original shipment. The first thing, therefore, is to examine the seals to see that they are unbroken. The inspector then samples and examines the wheat, and enters the grade upon a blank opposite the number and letters of the car. His tag and sample go to the wheat exchange or chamber of commerce, where they are exposed in small tin pans, and form the basis of the trading. A few years ago the wheat received from the North-West was very clean indeed, but since the new land has all been cultivated the fields are growing more weedy, with the result that the wheat brought in is becoming mixed with oats and seeds of weeds, requiring more careful separating and inspection. After the inspector has finished his work the cars are resealed with the State seal, and await the orders of the purchaser. The delay will not ordinarily be more than one day. The Commission keeps complete records and samples of each car until the wheat has passed entirely out of the market. When disputes occur as to the grade they can thus be instantly settled. If the grade is changed after a second examination the State pays the expense of the inspection; if not, it is paid by the agent who raises the objection. Only about 5 per cent. of the samples are ever reinspected, and in less than 2 per cent. of these is the grade changed. The Commission collects the small fee of 20 cents a car for its services as inspector, and later weighs all the wheat as it is distributed into the elevators. This small charge pays all the expenses.

The transportation of the wheat from the fields of the North-West to the seaport is a business of tremendous magnitude. Most of this wheat goes by way of the lakes through the Sault de Sainte Marie canal to Buffalo, where

S. I. — 28

Transportation.

it is shipped by rail or inland canal to New York, Philadelphia, or Baltimore. Duluth, on Lake Superior, is, surprising to say, the second port in the United States in point of tonnage. The Sault de Sainte Marie canal passes two and a half times as much tonnage during the eight months it is open as the Suez canal passes in the entire year. The cheapest transportation in the world is found upon these lakes, the rate being only three-fourths of a mill per ton of wheat per mile. The greater lake vessels, called "Whalebacks," carry cargoes up to 250,000 bushels, a bulk difficult to conceive. 700 bushels is a car-load. At that rate the cargo of 250,000 bushels will fill 360 American cars, or 9 trains of 40 cars each. At 20 bushels to the acre, this single cargo would represent the yield of two and a half farms of 5000 acres each, like that described above, with every acre in cultivation. The railways of the North-West have a monopoly of the business of hauling wheat, with the result that it costs 20 cents to ship a bushel of wheat from the Dakota fields to Duluth, which is as much as it costs to forward it from Duluth to Liverpool. The bushel of wheat, or an equivalent amount of flour, can be shipped from Minneapolis or Duluth to almost any point in western Europe for from 20 to 25 cents.

Prospects of wheat production.

What are the prospects of wheat production in the United States? In his presidential address before the British Association for the Advancement of Science (1900), Sir William Crookes painted a rather dark picture of the future of the world's wheat production. Among other things he said, "It is almost certain that within a generation the ever-increasing population of the United States will consume all the wheat grown within its borders, and will be driven to import like ourselves." Americans think that this statement is altogether too pessimistic. Not sufficient account had been taken of the uncultivated land in farms, and of the possibilities of improving the yield, and still further cheapening the product. It is probable that the United States will by 1933 have a population of 133,000,000. This population would require a wheat crop of 700,000,000 bushels for its own use alone. Limiting attention to the great cereal-producing region described above, let us see what the prospects are for increasing the acreage and the yield. The fact that these States contain, according to the last census, over 100,000,000 acres of unimproved land, already enclosed in farms, suggests at once the great possibilities in wheat. But all this land is not immediately available for cultivation. The availableness of the unimproved land in these States is chiefly a question of population and physical features. In States like New York and Pennsylvania, which are much broken up by hills and mountains, and have already a large population, it is probable that the land available for wheat cultivation is now nearly all taken up, although they still have 30 per cent. of unimproved land in farms. In the great States of Michigan, Missouri, Wisconsin, Minnesota, and the Dakotas there is still 40 to 50 per cent. of unimproved land in farms. There are few mountains and hills in these States, and there is still room in them for a large population. It is evident that in States like these wheat culture is destined to increase greatly. Twelve States in this vast cereal-growing region —Ohio, Indiana, Illinois, Missouri, Kansas, Nebraska, Michigan, Iowa, Wisconsin, Minnesota, North and South Dakota—still have from 20 to 40 per cent. of unimproved land in farms. The total area of these States is nearly four times that of France. Their soil is primarily as fertile as hers. If we put the population of France at 40,000,000, the States in question could, at the same ratio, support a population of 140,000,000. France produced during the five years ending 1897 eight bushels of wheat per caput. At eight bushels per caput, the people in these twelve States alone could produce 1,120,000,000 bushels, or 420,000,000 bushels more than will be required by the population of 133,000,000 expected by 1933. This is a great manufacturing as well as a great agricultural region, and it is here, therefore, that a large part of this increase in population will be found.

It is evident that there is great room for improvement also in the matter of yield per acre. The average yield of wheat per acre has increased slowly in recent years. So long as there was so much virgin land to be brought under cultivation, it is surprising that it has increased at all, since the tendency everywhere is to "skin" the rich, new lands first. Mr B. W. Snow, formerly one of the statisticians of the United States Department of Agriculture, has shown (*The Forum*, vol. xxviii. p. 94) that the producing capacity of the wheat lands, under favourable weather, increased steadily during the period 1880-1899. He distinguishes between the actual yield and the producing capacity, and bases his comparison upon the latter. He takes the average for each year of five years between 1880 1899, and shows that the producing capacity per acre increased 0·5 bushel between the first and the second period, 1·3 bushels between the second and the third, and 1·4 bushels between the third and the fourth. In the period 1880-84, inclusive, the maximum capacity was a little less than 14 bushels, while in the period 1895-99 the maximum capacity exceeded slightly 17 bushels—an increase of 3·2 bushels per acre, or 23 per cent., in less than twenty years. He says, "To account for this increase in the potential yield in our wheat-fields many factors must be taken into consideration. Among these may be mentioned improved methods of ploughing, tile drainage, use of the press drill, which results in greater immunity against winter killing, crop rotation, and, to a very small extent, fertilization. An important factor to be mentioned in this connexion is the change in the distribution of the acreage under wheat, consequent upon falling prices. A decline in the price of wheat rendered its production unprofitable where the rate of yield was small. Gradually these lands were passed over to crops better suited to them; while at the same time the wheat acreage was increased in districts having a better rate of yield." He predicts that "the increase in the acre yields in this country has only begun. All that has been accomplished during the period under review may be attributed to improvements in implements for preparing the soil and planting the seed. Wheat is grown year after year without rotation—except in a few cases—on a third or more of our wheat acreage; not one acre in fifty is directly fertilized for the crop, and only a minimum amount of attention is given to the betterment of seed stock. If, in the face of what cannot be considered less than careless and inefficient agricultural practice, we have increased the wheat capacity of our land by 3·2 bushels per acre in so short a time, what may we not expect in the way of large acre yields before we experience the hardships of a true wheat famine?"

Cotton.

Soil and climatic conditions restrict the cultivation of cotton to a group of States in the southern portion of America constituting less than one-fourth of the total area of the United States, yet these States grow over 60 per cent. of all the cotton consumed in the world. The total value of the annual crop is exceeded among the cultivated crops of the United States only by Indian corn, which is grown in every State, and about one year in four by wheat, which is grown in almost every State. Its production engages almost exclusively 7,000,000 of the people, and its handling for domestic and foreign markets employs the capital or labour of several millions more.

Cotton is limited by climatic conditions to the States south of latitude 37° N. The essential features of the climate in this section are the long warm season and the peculiar distribution of the rainfall. Cotton is a sun plant. Fluctuations in yield per acre in a given place are less in the case of cotton than in any other product of the soil; in other words, a certain amount of sunlight produces a certain amount of cotton. This may be due to the greater uniformity of all the climatic conditions obtaining in the cotton belt; but the determining condition as between different sections is the amount of light and heat distributed over the required number of months. This period is ordinarily measured by the date of the last killing frost in the spring and of the earliest frost in the fall. Cotton-picking may be extended far into the winter, but the first killing frost stops the active growth of the plant, and by killing the blossoms and young bolls puts an end to the production of cotton for that season. Cotton requires for its development from six to seven months of favourable growing weather. It thrives in a warm atmosphere, even in a very hot one, provided it is moist and the transpiration does not overtax the leaves. The plant requires, however, an abundant supply of moisture during the growing stage. A rainfall increasing from the spring to the middle of summer and then decreasing to autumn is probably the most favourable condition for the production of this crop. These are exactly the conditions that prevail in the cotton States. Cotton grows more or less successfully on nearly all kinds of soil within this climatic belt. Light sandy soils, loams, heavy clays, and sandy "bottom lands" will all grow it, though not with equal success. Sandy uplands produce a short stalk, which bears fairly well. Clay and bottom lands grow a plant of large size, yielding less lint in proportion. The best soils for cotton are the medium grades of loam. The cotton soil should be of a quality to maintain very uniform conditions of moisture. Sudden variations in the amount of water supplied injure the plant decidedly. A sandy soil does not retain water; a clay soil maintains too much moisture and causes the plant to take on too rank a growth. The best soil for cotton, therefore, is a deep, well-drained loam. Cotton is successfully grown in the south on nearly all kinds of soils, from the piny ridge soils of North Carolina to the rich bottom soils on the Mississippi.

The cotton-growing States include those on the Atlantic slope from North Carolina to Florida and on the gulf from Florida to New Mexico; also the south-western portion of Tennessee, the State of Arkansas, and a portion of Oklahoma. A little cotton has also been grown in Utah and California. The cotton-growing region measures over 550,000 square miles, which is about one-fourth of the total, or one-third of the settled, area of the United States. In 1890 over 50 per cent. of this was in farms, and over 20 per cent. was improved, but only about 5 per cent. of the total area, or one-tenth of the area in farms, and one-fourth of the area of improved land, is annually cultivated in cotton. Since the present methods of cultivation require about two and one-half acres to produce one 400-pound bale, the area now in farms in this section would, if all cultivated in cotton, produce over 80,000,000 bales. So far, therefore, as climatic conditions are concerned, the Southern States could produce eight times as much cotton as they have ever done without taking in any more land.

Labour.

The question of labour required for the production of a cotton crop is a serious one. Expert estimates place the amount of human labour at about 54 per cent. of the whole expense of growing the crop. This is a much higher ratio of the cost of labour than is found in most other industries. It exceeds the cost of labour in corn, and wheat-growing, and also in manufacturing industries. In the cotton mills reporting to the Department of Labour the average cost of labour employed is only about 28 per cent. In 1880 the people in the cotton belt produced an average of 231 pounds of cotton per caput; in 1890 this had been increased to 254; and in the State of Mississippi, where conditions are most favourable, the production per caput was 427 pounds in 1889. With their present population, and under present conditions, the Southern States yield 300 pounds per caput. The total population of the cotton States may be fairly placed at 15,000,000. This population could easily produce a far larger crop than it does now, for there is great room for improvement in methods of cultivation and fertilization. There are three classes of farmers engaged in cotton cultivation, namely, owners of the land, renters who pay money rental, and share croppers. In the ten principal cotton States, according to the census of 1890, there were 57 per cent. of the first class, 15 per cent. of the second, and 28 per cent. of the third.

The result of a careful inquiry as to the cost of producing cotton in the United States, made in 1897 by the Department of Agriculture, gives an average cost per acre on upland farms of $15.42 and the average total return of cotton fibre and seed $19.03, the average net profit being $3.61. The average yield is 255·6 pounds of lint and 16 pounds of seed per acre, and the average price of lint 6·7 cents per pound and of seed 11·9 cents per bushel. The average cost of picking one hundred pounds of cotton is 44 cents and the average cost of producing lint cotton in all the States and territories is 5·27 cents per pound. Eighty per cent. of the cotton plantations reporting in 1896 showed a profit and 20 per cent. a loss.

Production and Exports.

Figure 1 shows in a graphic manner the record of cotton production in the United States every tenth year from 1790 to 1890, and also for the year 1895; the portion of each crop consumed at home (divided between north and south), and the portion exported.

A cotton crop of 9,000,000 bales, such as that of 1899, represents at 7 cents a pound a money value of $300,000,000. Of this amount, 70 per cent. is exported, bringing into the country about $210,000,000. Basing the calculation on the average price of each year, the cotton crops in America for the last one hundred years have been worth $15,000,000,000. During the hundred years about 82,000,000,000 pounds have been exported, representing a value of $11,000,000,000. In 1790 Great Britain received from America something less than one six-hundredth part of her total cotton imports, but only fifty years later she received from the Southern States four-fifths of all the cotton she used; and the South has always maintained and still maintains its position in relation to the cotton consumption of the world. It has never supplied less than 80 per cent. of the cotton used by Great Britain and the United States together, and in 1892 the Southern cotton formed 82 per cent. of the total amount consumed in these two countries.

In the next chart (Fig. 2) an attempt is made to present in somewhat greater detail the chief facts with regard to area, production, exports, and values of the cotton crop during the ten years from 1886 to 1896. It shows that an average area of a little less than 20,000,000 acres, cultivated each year, has produced in these ten years a total of over 36,000,000,000 pounds, valued at more than $3,000,000,000. Of the total production of these ten years we exported 24,600,000,000 pounds, worth $2,250,000,000. The amount exported was 68·3 per cent. of the entire production, leaving only 31·7 per cent. for home consumption. The average yield per acre during the last ten years was only 181 pounds and the average New York price was nearly 9 cents per pound, making the average value per acre nearly $16.

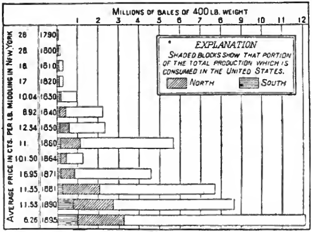


Fig. 1.

Most interesting and instructive are the results of the **Fertilizers.** investigations made by the Department of Agriculture in 1897 with regard to the use of fertilizers upon cotton. They show that no plant responds more promptly or more generously to judicious fertilization than does the cotton plant. The results obtained upon about fifteen hundred representative cotton plantations in the five Atlantic coast States—North Carolina, South Carolina, Georgia, Alabama, and Florida, where fertilizers have been longest and most used—were tabulated according to the cost of fertilizer per acre. Six classes were formed, ranging from under one dollar's worth to six dollars' worth and over of fertilizer. The planters who spent an average of 74 cents for fertilizers per acre made an average profit of $4.62; those who spent from $1.00 to $2.00 for fertilizers made a profit of $5.09; from $2.00 to $3.00, a profit of $5.34; from $3.00 to $4.00, a profit of $5.91; from $4.00 to $5.00, a profit of $7.96; from $5.00 to $6.00, a profit of $8.76; and those whose fertilizers cost them $6.00 and more per acre made a profit of $12.51. The word *profit* was used in this investigation to mean "the excess of returns over expenses, including the theoretical one of rent." "Some small charges, such as insurance, repairs, renewals, and supervision, were omitted." "It is evident from the figures above that the point of diminishing returns was not reached, when the crop was profitable, at any degree of fertilization." The total number of plantations reporting losses is only 15 per cent. "The returns from the planters who suffered a loss, while at first seeming to indicate a conclusion contrary to the above, in reality do not, because their crops were subject to abnormal conditions and were partial failures, the cause generally having been a drought." "In cases of the planters who lost on their crops the loss is greater as the cost of fertilizers is greater; but had climatic conditions been favourable, the loss would have been a profit." Co-operative experiments by selected farmers, directed by the experiment stations, show that the application of 60 pounds of nitrogen, 20 pounds of potash, and 20 pounds of phosphoric acid in suitable form, made on fair average land, containing a reasonable amount of humus, such, for example, as would without fertilizer produce 250 pounds of lint per acre, would usually double this crop. Cotton-seed meal, the offal of fisheries, abattoirs, &c., are the commonly used sources of nitrogen; the superphosphates are made from

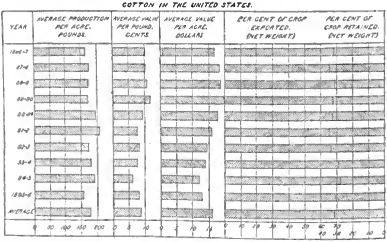


Fig. 2.

Carolina, Tennessee, or Florida phosphates; and the potash salts are imported from Germany. These are commonly mixed to produce a fertilizer containing about 2½ per cent. of nitrogen, 9 per cent. of soluble and reverted phosphoric acid, and 2 per cent. of potash. Such a fertilizer can usually be laid down upon the farms in the cotton country for about $5.00 per acre for the above amounts. Five dollars invested in this kind and amount of fertilizer will, upon land of the character described, with favourable weather, produce an increase in the crop amounting to $10.00 to $15.00. Fertilizers are gradually being introduced throughout the cotton country, with the exception of the rich bottoms of the Mississippi and the black prairies of Texas, where they have so far never been needed.

Great improvements have also been made in the implements and in the methods of cultivation. This crop, which under the slave system was cultivated almost entirely with the hoe, is now cultivated wholly with machines. On many plantations the hoe is used only once, to thin the cotton. The culture is carried out with horse cultivators and is prosecuted as long as the growth of the plant continues, or until the actual fruiting begins. According to the reports to the Department of Agriculture the percentage of each item in the total average cost of cultivating a crop of cotton is as follows:—Rent of land, 19; ploughing, 18; seed, 1; planting, 2; fertilizers and distributing, 9; thinning and hoeing, 8; picking, 22; ginning and pressing, bagging and ties, 11; wear and tear on implements, 3; marketing and other expenses, 7 per cent. It will be seen that picking is much the most expensive item in cotton cultivation. The great desideratum still is the cotton-picking machine.

Varieties.

The cotton-plant has undergone a remarkable development since its introduction in the southern States. The cultivated cottons of to-day differ much from the original form of *Gossypium herbaceum*, which produced seed cotton, whose lint was only 25 per cent. of its weight, and had a staple only 20 to 30 mm. long. Under the influence of the climate, soils, and cultivation of these States the proportion of lint has been greatly increased, reaching as high as 36 and even 40 per cent. in some varieties; while the length of the staple has increased correspondingly, reaching in a few varieties a length of 50 or even 60 mm. In only a few varieties, however, have we obtained this great increase in both percentage of lint and length of staple. Usually, when the length and fineness of the staple are increased the weight is reduced, and *vice versâ*. In cases where both length of fibre and weight have been increased the cotton runs down again very rapidly, first usually in the weight produced. Cotton is a plant which supports easily and responds quickly to differences in environment, soil, climate, treatment, and manures, and can thus be greatly modified in form and habit in a few successive generations. The flowers are open; the pollen is produced in great abundance, and is borne upon the slightest breeze. The stigmas are well above the anthers, so that cross-fertilization is easy and common. Seeds from the earlier maturing bolls produce plants yielding a longer lint than those from the later-ripened bolls on the same plant. Some varieties produce a long, silky fibre when grown in rich, moist soil, but soon lose these qualities when grown on the poorer hill lands. A variety which has been grown for years in the northern belt of the cotton region will mature its whole crop at the same time, while the same variety grown for a few years in the southern part of the belt will continue to ripen through several weeks, though the total yield will be no greater. With this natural tendency to vary, and with all these forces to impel the plant to change its form or habit, varieties are multiplied indefinitely, even without the help of the cultivator. Of true botanical varieties, however, there are few, if any; while the agricultural varieties, so called, are almost innumerable. The result of this natural tendency of the plant is that the names of agricultural varieties are in great confusion, and there is a good deal of humbugging connected with the business of selling cotton-seed for planting. The natural tendency of this variation is always back towards its original form. Unusual fruitfulness always results in loss of vitality, and the original form, yielding a small crop, always has the greater vitality, and so a greater prepotency in cross-fertilization. As a result of this law, constant care in the selection of seed is essential in order even to keep an improved variety up to its present standard. Only the seed from the finest typical plants should be saved and used. The neglect of these principles leads surely to degeneration of the so-called improved variety. In this way planters are often disappointed with the results secured from high-priced seed of new varieties, for which great claims are made by their originators, and large prices paid. The old method of saving seed for planting was to take a sufficient number of bushels just as they came from the gin. The new method of selecting the best plants only of the typical form is resulting in the steady improvement of the cotton-plant. If it is intelligently pursued by a large number of planters for another century, or even a score or two of years, it will certainly result in the still further improvement of this wonderful plant. The great desire, of course, is to secure a cotton-plant which will yield a maximum amount of fibre of the longest and finest staple. It is believed by experts that cotton will be improved steadily until this end is reached.

Culture.

The culture of cotton must be a clean one. It is not necessarily deep culture, and during the growing season the cultivation is preferably very shallow. The result of this is a great destruction of the humus of the soil, and great leaching and washing, especially in the light loams of the hill country. The main object, therefore, of the cotton-planter is to prevent erosion. Wherever the planters have failed to guard their fields by hillside ploughing and terracing, these have been extensively denuded of soil, rendering them barren, and devastating other fields lying at a lower level, which are covered. The hillsides have to be gradually terraced with the plough upon almost an exact level. On the better farms this is done with a spirit-level or compass from time to time, and hillside ditches put in at the proper places. In the moist bottom-lands along the rivers it is the custom to throw the soil up in high beds with the plough, and then to cultivate them deep. This is the more common method of drainage, but it is an expensive one, as it has to be renewed every few years. More intelligent planters drain their bottoms with underground or open drains. In the case of small plantations the difficulties of adjusting a right-of-way for outlet ditches have interfered seriously with this plan. Many planters question the wisdom of deep-breaking and subsoiling. There is no question that a deep soil is better for the cotton-plant; but the expense of obtaining it, the risk of injuring the soil through leaching, and the danger of bringing poor soil to the surface, have led many planters to oppose this plan. Sandy soils are made thereby too dry and leachy, and it is a questionable proceeding to turn the heavy clays up upon the top. Planters are, as a result, divided in opinion as to the wisdom of subsoiling. Nothing definite can be said with regard to a rotation of crops upon the cotton plantation. Planters appreciate generally the value of broad-leaved and narrow-leaved plants and root crops, but there is an absence of exact knowledge, with the result that their practices are very varied. It is believed that the rotation must differ with every variety of soil, with the result that each planter has his own habit in this respect, and little can be said in general. A more careful study of the physical as well as the chemical properties of a soil must precede intelligent experimentation in rotation. This knowledge is still lacking with regard to most of the cotton soils. The only uniform practice is to let the fields "rest" when they have become exhausted. Nature then restores them very rapidly. The exhaustion of the soil under cotton culture is chiefly due to the loss of humus, and nature soon puts this back in the excellent climate of the cotton-growing country. Fields considered utterly used up and allowed to "rest" for years, when cultivated again, have produced better than those which had been under a more or less thoughtful rotation. In spite of the clean culture, good crops of cotton have been grown on some soils in the south for more than forty successive years. The fibre takes almost nothing from the land, and where the seeds are restored to the soil in some form, even without other fertilizers, the exhaustion of the soil is very slow. If the burning-up of humus and the leaching of the soil could be prevented, there is no reason why a cotton soil should not produce good crops continuously for an indefinite time. Bedding up land previous to planting is almost universal. The bed forms a warm seed-bed in the cool weather of early spring and holds the manure, which is drilled in usually, to better advantage. The plants are generally left 2 or 3 inches above the middle of the row, which in 4-foot rows gives a slope of 1 inch to the foot, causing the plough to lean from the plants in cultivating, and thus to cut fewer roots. The plants are usually cut out with a hoe from 8 to 14 inches apart. It seems to make little difference exactly what distance they are, so they are not wider apart on average land than 1 foot. On rich bottom-land they should be thinner. The seed is dropped from a planter, five or six seeds in a single line, at regular intervals, 10 to 12 inches apart. A narrow, deep furrow is usually run immediately in advance of the planter, to break up the soil under the seed. The only time the hoe is used is to thin out the cotton in the row; all the rest of the cultivation is by various forms of ploughs and so-called cultivators. The question of deep and shallow culture has been much discussed among planters without any conclusion applicable to all soils being reached. All grass and weeds must be kept down, and the crust must be broken after every rain, but these seem to be the only principles upon which all agree. The most effective tool against the weeds is a broad, sharp "sweep," as it is called, which takes everything it meets, while going shallower than most ploughs. Harrows and cultivators are used where there are few weeds, and the mulching process is the one desired. The date of cotton-planting runs from 1st March to 1st June, according to situation. Planting commences early in March in Southern Texas, and the first blooms will appear there about 15th May. Planting may be done as late as 15th April in the Piedmont region of North Carolina, and continue as late as the end of May. The first blooms will appear in this region about 15th July. Picking may commence on 10th July in Southern Texas, and continue late into the winter or until the rare frost kills the plants. It may not begin until the 10th of September in Piedmont, North Carolina. It is a peculiarity of the cotton-plant to lose a great many of its blooms and bolls. When the weather is not favourable at the fruiting stage the otherwise hardy cotton-plant displays its great weakness in this way. It sheds its forms, as the buds are called, its blooms, and even its half-grown bolls in great numbers. It has frequently been noted that even well-fertilized plants upon good soil will mature only 15 or 20 per cent. of the bolls put on. No means is known so far for preventing this great waste. Even experts are at an entire loss to form a correct idea of the cause or to apply any effective remedy.

TABLE XVI.—*Acreage, Production, and Value, Prices, and Exports of Cotton in the United States, 1875-1898.*[1]

Year.	Acreage.	Average Yield per Acre.	Production.	Average Farm Price per Pound.	Value.	New York Closing Prices per Pound on Middling Upland.				Domestic Exports, Fiscal Years beginning 1st July.
						December.		May of Following Year.		
						Low.	High.	Low.	High.	
	Acres.	Bales.	Bales.	Cents.	Dollars.	Cents.	Cents.	Cents.	Cents.	Bales of 500 pounds.
1875	10,803,030	·43	4,632,313	11·1	233,109,945	13 1/16	13 5/16	11 13/16	13 1/8	2,982,810
1876	11,677,250	·38	4,474,069	9·9	211,655,041	12 1/16	12 1/8	10 13/16	11 3/8	2,890,738
1677	12,600,000	·38	4,773,865	10·5	235,721,194	11 1/4	11 1/2	10 3/8	11 1/4	3,215,067
1876	12,266,800	·41	5,074,155	8·2	193,467,706	8 11/16	9 1/2	11 7/8	13 3/8	3,256,745
1879	12,595,500	·46	5,761,252	10·2	242,140,967	12 3/8	13 7/16	11 11/16	11 7/8	3,644,122
1880	15,475,300	·43	6,605,750	9·8	280,266,242	11 7/8	12	10 7/16	10 5/8	4,381,857
1881	16,710,730	·33	5,456,048	10·0	294,135,447	11 7/8	12 1/4	12 1/16	12 3/8	3,479,951
1682	16,791,557	·41	6,949,756	9·9	309,696,500	10 1/4	10 7/16	10 3/8	11 1/4	4,576,150
1683	16,777,993	·34	5,713,200	9·0	250,594,750	10 3/8	10 9/16	11 1/2	11 1/4	3,725,145
1884	17,439,612	·33	5,706,163	9·2	253,993,385	10 7/16	11 1/16	10 13/16	11	3,763,318
1885	18,300,865	·36	6,575,691	8·5	269,989,612	9 3/16	9 7/16	9 5/16	9 5/16	4,116,074
1886	18,454,603	·35	6,505,087	6·1	309,381,938	9 5/16	9 9/16	10 3/8	11 7/16	4,838,914
1687	16,641,087	·36	7,046,833	6·5	337,973,438	10 1/4	10 1/2	9 13/16	10 1/16	4,528,241
1886	19,058,591	·36	6,938,290	8·5	354,454,340	9 3/4	9 7/8	11	11 5/16	4,769,633
1889	20,171,696	·36	7,311,322	8·3	402,951,814	10 1/4	10 1/2	11 13/16	12 3/4	4,943,599
1890	20,809,053	·42	8,652,597	8·6	369,568,858	9 5/16	9 7/16	8 3/8	8 13/16	5,814,717
1891	20,714,937	·44	9,035,379	7·3	326,513,296	7 3/4	8 3/16	7 1/4	7 5/16	5,870,439
1892	18,067,924	·37	6,700,365	6·4	262,252,286	9 5/8	10	7 1/4	7 13/16	4,424,230
1893	19,525,000	·39	7,549,817	7·0	274,479,637	7 13/16	8 3/16	7 1/8	7 3/8	5,366,564
1894	23,687,950	·42	9,901,251	4·6	287,120,818	5 11/16	5 13/16	6 3/8	7 1/8	7,034,866
1895	20,184,808	·36	7,161,094	7·6	260,338,096	8 1/4	8 9/16	8	8 3/8	4,670,452
1696	23,273,209	·37	8,532,705	6·6	291,811,564	7 3/16	7 5/16	7 3/8	7 13/16	6,207,509
1897	24,319,584	·45	10,897,857	6·6	319,491,412	5 13/16	5 15/16	6 5/16	6 5/16	7,700,528
1898	24,967,295	·45	11,189,205	5·7	305,467,041	5 5/8	5 3/8	7 1/8	6 1/4	7,546,820

[1] From the *Year-Book*, U.S. Department of Agriculture, for 1899.

Cotton-picking is at once the most difficult and most expensive operation in cotton production. It is paid for at the rate of from 45 to 50 cents per cwt. of seed cotton. This is light work, and is effectually performed by women and even children, as well as by men; but it is tedious, and requires care. The picking season will average 100 days. It is difficult to get the hands to work until the cotton is fully opened, and it is hard to induce them to pick over 100 ℔ a day, though some expert hands are found in every cotton plantation who can pick twice as much. The loss resulting from careless work is very serious. The cotton falls out easily or is dropped. The careless gathering of dead leaves and twigs, and the soiling of the cotton by earth or by the natural colouring matter from the bolls, injure the quality. It has been commonly thought that the production of cotton in the south is limited by the amount that can be picked, but this limit is evidently still very remote. The negro population of the towns and villages of the cotton country is usually available for a considerable share in cotton-picking. There is in the cotton States a rural population of over 7,000,000, more or less occupied in cotton-growing, and capable, at the low average of 100 ℔ a day, of picking daily nearly 500,000 bales. It is evident, therefore, that if this number could work through the whole season of 100 days, they could pick three or four times as much cotton as the largest crop ever made.

Picking.

The comparative figures in Table XVII., compiled from the reports of the bureau of statistics of the Treasury Department, show the number of bales of cotton exported to each foreign country in 1889, as compared with the years 1898 and 1899. All bales are reduced to the uniform weight of 500 pounds each.

TABLE XVII.—*Exports of Cotton from United States to Foreign Countries.*[1]

In Bales of 500 pounds.

Countries.	Year ending 30th June 1889.		Year ending 30th June 1898.		Year ending 30th June 1899.	
	Bales.	Value.	Bales.	Value.	Bales.	Value.
Austria-Hungary	5,610	$275,275	35,614	$987,724	57,127	$1,576,175
Belgium	147,807	7,556,687	161,942	4,809,609	129,525	3,599,471
Denmark	...	...	24,741	782,810	39,249	1,078,300
France	400,196	20,174,839	842,038	24,599,724	803,406	21,946,691
Germany	660,756	32,308,593	1,858,524	54,856,245	1,728,975	47,346,679
Italy	131,068	6,460,413	387,581	11,468,025	417,353	11,652,768
Netherlands	44,354	2,188,771	43,509	1,292,788	51,621	1,401,040
Portugal	...	...	18,835	588,923	21,627	612,132
Russia	144,036	7,506,201	103,825	3,133,758	95,011	2,796,798
Spain	161,533	9,200,998	263,648	8,180,970	248,635	7,194,100
Sweden and Norway	8,717	420,412	25,613	744,287	23,624	703,503
United Kingdom	2,940,800	146,605,505	3,532,101	105,853,614	3,609,444	99,709,352
Rest of Europe	9,547	475,182	...	...	...	...
Dominion of Canada	61,143	2,980,556	122,495	3,961,586	98,230	2,994,674
Mexico	33,803	1,607,395	42,433	1,321,473	36,130	1,043,473
West Indies (French)	...	...	17	653	5	187
China	...	...	11,302	370,670	4,060	131,734
East Indies (British)	...	...	297	9,130	9	308
Hong-Kong	...	...	1,800	72,000	56	1,710
Japan	47	2,341	224,214	7,428,226	182,734	5,774,784
All other countries	216	12,102	...	...	...	...
Total	4,769,633	237,775,270	7,700,529	230,442,215	7,546,821	209,563,874

[1] From the *Year Book*, U.S. Department of Agriculture, for 1899.

Except in the cases of Belgium and Russia, the increase in exports has been very large, in some cases the amount being more than double what it was eight or ten years earlier. Notwithstanding a net decrease of 153,708 bales in 1899 as compared with 1898, these two years are conspicuous as having recorded the largest exports of cotton in the history of the United States (see Table XVI.). The extremely low prices in 1897-98 and 1898-99 reduced the export values $7,333,055 in the former, and $28,211,396 in the latter year, as compared with those of 1889, although the number of bales exported in 1898 was 2,930,896, and in 1899 was 2,777,188 greater than in 1889.

While there are no available statistics showing the annual crops of all the cotton-producing countries, the consumption of the mills in Great Britain, the Continent of Europe, the United States, India, Japan, Canada, Mexico, and other countries fairly approximates the world's production. The following statistics (Table XVIII.) taken from Dr Thomas Neilson's *Annual Review of the Cotton Trade*, issued in Liverpool, 1st November 1899, show the number of bales of cotton consumed by the mills of the world from 1890-91 to 1898-99, inclusive:—

TABLE XVIII.—*The World's Consumption of Cotton,* 1890-91 to 1896-99.

In bales of 500 pounds.

Year ended Sept. 30.	Great Britain.	Continent of Europe.	United States.	India.	All other Countries.	Total.
1891	3,384,000	3,631,000	2,367,000	924,000	150,000	10,456,000
1892	3,181,000	3,640,000	2,576,000	914,000	160,000	10,471,000
1893	2,866,000	3,692,000	2,551,000	918,000	220,000	10,247,000
1894	3,233,000	3,848,000	2,264,000	959,000	250,000	10,554,000
1895	3,250,000	4,030,000	2,743,000	1,074,000	300,000	11,397,000
1896	3,276,000	4,160,000	2,572,000	1,106,000	419,000	11,532,000
1897	3,224,000	4,368,000	2,738,000	1,004,000	488,000	11,822,000
1898	3,432,000	4,628,000	2,962,000	1,141,000	716,000	12,876,000
1899	3,519,000	4,836,000	3,553,000	1,297,000	727,000	13,932,000

These figures certainly show a very large increase in the consumption of cotton, the increase in all countries in 1898-99 over the previous year amounting to 1,056,000 bales, of which more than one-half was in the United States, while the increase in all countries since 1890-91 amounts to 3,476,000 bales. In 1898-99 this increase, as compared with the previous year, amounts to 591,000 bales, as against 208,000 in all continental European countries, 156,000 in India, and 87,000 in Great Britain. Since 1890-91 the United States shows an increase of 1,186,000 bales, as compared with 1,205,000 in all continental European countries, 373,000 in India, and 135,000 in Great Britain.

Prices of all products entering the world's markets tend to fluctuate less and less with the development of transportation, the telegraph, the crop reporting system, and the publication of market news. Present prices are raised or lowered in anticipation of higher or lower prices in the future. This is well illustrated by the prices of cotton shown in Table XIX.

The range of prices was higher and the fluctuations were more violent in the decades 1821-30 and 1831-40, than during any other decades except that of the Civil War (1861-70). There has been a gradual diminution in the range of prices, the fluctuations being less during the decade 1881-90 than at any other period. The greatly increased crops since 1890 have depressed the price very much, causing a slightly increased range. But the tendency is towards a permanently narrow range of fluctuations.

The use of improved implements, the introduction of better methods of cultivation, the establishment of a more economical system of labour, and especially the use of fertilizers, have cheapened considerably the cost of cotton production—exactly how much, however, it is impossible to say. Until recent years no accurate records of the cost of cotton production were kept. So long as cotton brought a high price, the planters were extravagant in their methods of culture, and the factors and transportation companies excessive in their charges. The low prices of cotton which have prevailed for a number of years have taught farmers how to make cotton more economically and how to get the full value of it after it is made, with the result that they are in better condition now to produce cotton at a steady and trustworthy profit than they ever were before.

TABLE XIX.—*Showing the Range of Prices of Middling Upland Cotton, per Pound, in New York from* 1821 *to* 1895, *inclusive.*

Year.	Range of Prices.	Year.	Range of Prices.	Year.	Range of Prices.	Year.	Range of Prices.
	Cents.		Cents.		Cents.		Cents.
1821	9·00	1841	4·50	1861	12·00	1881	2·50
1822	8·00	1842	5·50	1862	31·50	1882	1·50
1823	8·00	1843	2·37	1863	41·00	1883	2·87
1824	8·50	1844	3·75	1864	121·00	1884	1·00
1825	18·00	1845	1·75	1865	147·00	1885	1·00
1826	8·50	1846	2·50	1866	27·50	1886	·87
1827	2·75	1847	5·25	1867	15·50	1887	2·25
1828	4·75	1848	7·00	1868	17·50	1888	1·50
1829	3·50	1849	4·75	1869	10·75	1889	1·81
1830	4·50	1850	3·87	1870	15·75	1890	2·37
Aver.	7·35	Aver.	4·12	Aver.	43·95	Aver.	1·77
1831	5·75	1851	6·25	1871	6·25	1891	2·69
1832	5·00	1852	2·87	1872	8·37	1892	2·06
1833	7·50	1853	2·00	1873	3·12	1893	2·81
1834	8·50	1854	1·75	1874	7·87	1894	1·69
1835	7·50	1855	4·50	1875	2·82	1895	1·81
1836	7·50	1856	2·82	1876	2·87		
1837	12·50	1857	4·12	1877	2·37	Aver.	2·21
1838	8·75	1858	6·87	1878	1·50		
1839	7·50	1859	2·37	1879	4·37		
1840	7·50	1860	1·25	1880	2·75		
Aver.	7·80	Aver.	3·48	Aver.	4·16		

COTTON SEED.

The history of no agricultural product contains more of interest and instruction for the student of economics than does that of cotton seed. The revolution in its treatment is a real romance of industry. Up till 1870, or thereabouts, it was regarded as a positive nuisance upon the plantation. It was left to accumulate in vast heaps about ginhouses, to the annoyance of the farmer and the injury of his premises. For cotton seed in those days was the object of so much aversion that the planter burned it or threw it into running streams, as was most convenient. If the seed were allowed to lie about, it rotted, and hogs and other small animals, eating it, often became sick and died. It was very difficult to burn, and when dumped into rivers and creeks, was carried out by flood water to fill the edges of the flats with a decaying mass of vegetable matter which gave rise to offensive odours and malaria. Although used in the early days to a limited extent as a food for milch cows and other stock, and to a larger extent as a manure, no systematic efforts were made anywhere in the South to manufacture the seed until the later 'fifties, when the first cotton seed mills were established. It is said that there were only seven cotton oil mills in the South in 1860. The cotton-growing industry was interrupted by the Civil War, and the seed-milling business did not begin again until 1868. Since that time the number of mills has been rapidly increasing. There were 25 in the South in 1870, 50 in 1880, 120 in 1890, and about 500 in 1901.

Long experience shows that 1000 pounds of seed are produced for every 500 pounds of cotton brought to market. On the basis, therefore, of a cotton crop of 10,000,000 bales of 500 pounds, there were produced in the South in 1900, 5,000,000 tons of cotton seed. About 3,000,000 tons only are pressed, producing products worth $65,000,000 at present prices. There remains, therefore, to be utilized on the farm 2,000,000 tons of cotton seed, which, if manufactured, would produce a total of $100,000,000 from cotton seed. In contrast with the farmers of the 'sixties, the southern planter of to-day appreciates the value of his cotton seed, and farmers, too remote from the mills to get it pressed, now feed to their stock all the cotton seed they conveniently can, and use the residue either in compost or directly as manure. The average of a large number of analyses of whole cotton seed gives the following figures for its fertilizing constituents:—Nitrogen, 3·13 per cent.; phosphoric acid, 1·27 per cent.; potash, 1·17 per cent.; besides small amounts of lime, magnesia, and other valuable but less important ingredients. Using average prices paid for nitrogen, phosphoric acid, and potash, when bought in large quantities and in good forms, these ingredients, in a ton of cotton seed, amount to $9.00 worth of fertilizing material. Compared with the commercial fertilizer which the farmer has to buy, cotton seed possesses therefore a distinct value.

The products of cotton seed have become important elements in the national industry of the United States. The main product is the refined oil, which is used for a great number of purposes, such as salad oil, compound lard, miners' oil, and the like. The poorer grades are employed in soap-making. Cotton seed cake or meal is one of the most valuable of feeding stuffs, as the following simple comparison between it and oats and corn will show:—

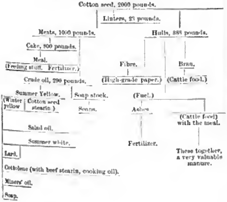
Average Analyses.	Proteins or Flesh Formers.	Carbo-hydrates or Fuel and Fat Suppliers.	Fats.	Ash or Bone Makers.
Cotton seed meal .	43·26	22·81	13·45	7·02
Corn . . .	10·5	70·0	5·5	1·02
Oats . . .	17·0	65·0	8·0	1·2

Cotton seed meal, though poor in carbo-hydrates, the fat and energy-supplying ingredients, is exceedingly rich in protein, the nerve- and muscle-feeding ingredients. But it still contains a large amount of oil, which forms animal fat and heat, and thus makes up for part of its deficiency in carbo-hydrates. The meal, in fact, is so rich in protein that it is best utilized as a food for animals when mixed with some coarse fodder, thus furnishing a more evenly-balanced ration. In comparative valuations of feeding stuffs, it has been found that cotton seed meal exceeds corn meal by 62 per cent., wheat by 67 per cent., and raw cotton seed by 26 per cent. Cotton seed meal, in the absence of sufficient stock to consume it, is also used extensively as a fertilizer, and for this purpose it is worth, determining the price on the same basis as used above for the seed, from $19 to $20 per ton. But it has seldom reached this price, except in some of the Northern States, where it is used for feeding purposes. A more rational proceeding would be to feed the meal to animals and apply the resulting manure to the soil. When this is done, from 80 to 90 per cent. of the fertilizing material of the meal is recovered in the manure, only 10 to 20 per cent. being converted by the animal into meat and milk. The profit derived from the 20 per cent. thus removed is a very large one. These facts indicate that we have here an agricultural product, the market price of which is still far below its value as compared, on the basis of its chemical composition, either with other feeding stuffs or with other fertilizers. Though it is probably destined to be used even more extensively as a fertilizer before the demand for it as a feeding stuff becomes equal to the supply, practically all the cotton seed meal of the South will ultimately be used for feeding. One explanation of this condition of things is that there is still a large surplus of cotton seed which cannot be manufactured by the mills, at least under the existing arrangements for its transportation. Another reason is found in the absence of cattle in the South to eat it.

With the consideration of cotton seed oil and meal we have not, however, exhausted its possibilities. Cotton seed hulls constitute about half the weight of the ginned seed. After the seed has been passed through a fine gin, which takes off the short lint left upon it by the farmer, it is passed through what is called a sheller, consisting of a revolving cylinder, armed with numerous knives, which cut the seed in two and force the kernels from the shells. The shells and kernels are then separated in a winnowing machine. This removal of the shell makes a great difference in the oilcake, as the decorticated cake is more nutritious than the undecorticated. For a long time these shells or hulls, as they are called, were burned at oil mills for fuel, two and a half tons being held equal to a cord of wood, and four and a third tons to a ton of coal. The hulls thus burned produced an ash containing an average of 9 per cent. of phosphoric acid and 24 per cent. of potash—a very valuable fertilizer in itself, and one eagerly sought by growers of tobacco and vegetables. It was not long, however, before the stock-feeder in the South found that cotton seed hulls were an excellent substitute for hay. They are now fed on a very large scale in the vicinity of oil mills in southern cities like Memphis, New Orleans, Houston, and Little Rock, from 500 to 5000 cattle being often collected in a single yard for this purpose. No other feed is required, the only provision necessary being an adequate supply of water and an occasional allowance of salt. Many thousands of cattle are fattened annually in this way at remarkably low cost. For this purpose hulls sell at from $2.50 to $3 per ton.

The following diagram, modified from one by Grimshaw, in accordance with the results obtained by the better class of modern mills, gives an interesting *résumé* of the products obtained from a ton of cotton seed :—

Products from a Ton of Cotton Seed.



RICE.

Rice production in the United States is limited to that portion of the South Atlantic States nearest the sea. For two decades prior to 1861 the annual production of rice in North Carolina, South Carolina, and Georgia averaged more than 1,000,000 pounds of the clean grain. South Carolina produced over three-fourths of this. This industry was wrecked by the Civil War and has never been fully restored. From 1866 to 1880, inclusive, the annual production of these three States averaged only about 40,000,000 pounds, of which South Carolina produced one-half. Since 1880 their average annual production has been 46,000,000 pounds, of which South Carolina produced 27,000,000. Since the Civil War the rice industry has been developing steadily in Louisiana; it averaged nearly 30,000,000 pounds for the decade 1870-80, 71,000,000 pounds in 1880-90, and obtained its greatest development in 1892, when it reached 182,000,000 pounds. The annual production is only about one-half as great as the annual consumption. The only statistics available are those made up by commercial companies, and represent only the amounts placed upon the market. The quantities consumed at home and retained for seed are considerable, but cannot be ascertained. The following table is from statistics reported by Dan Talmage's Sons Co., and gives the annual average market production of rice for the periods 1881-90 and 1891-98 :—

TABLE XX.—*Annual Average Market Production of Rice in the United States for the periods* 1881-90 *and* 1891-98.

Periods.	North Carolina.	South Carolina.	Georgia.	Louisiana.	Total.
1881-90	7,135,870	28,403,940	16,919,910	71,409,961	123,869,681
1891-98	3,941,712	25,281,895	9,423,064	104,348,675	143,005,346

The annual imports of rice in the United States for 1894 to 1899 averaged 121,000,000 pounds, and the imports of broken rice, flour, and meal, 63,000,000 pounds—the whole having an average annual value of $3,200,000.

FLAX AND HEMP.

The total number of acres devoted to the cultivation of flax for seed and fibre, both in 1889, was only 1,318,698. The production of flax seed was 10,250,000 bushels and the production of fibre 242,000 pounds. Throughout the greater portion of the flax-producing region the straw is not utilized, even for tow or for paper-making. That portion of the flax straw having a determinable value was only 207,757 tons. The total value of all flax products in 1889 was $10,436,000. The imports of flax fibre and manufactured goods amount to from $16,000,000 to $18,000,000 a year, and $2,000,000 to $3,000,000 of this represents raw flax fibre. In consideration of these facts, the United States Department of Agriculture is making special efforts to establish the flax fibre industry in the United States. Experiments have been carried on in Minnesota, Oregon, and Washington, which indicate that flax can be successfully grown for fibre in these States. In 1860 nearly 100,000 tons of hemp (*Cannabis sativa*) were produced, while in 1895 hardly more than 5000 tons were reported for the whole country. The introduction of Manila hemp, the large importation of jute, and the decline in American shipbuilding are the reputed causes for this falling-off. The census of 1890 showed 25,000 acres in hemp, yielding 11,500 long tons, worth $1,102,000. Nearly all of this was grown in the State of Kentucky.

TOBACCO.

The tobacco crop of 1889 amounted to 488,256,646 pounds, grown upon 695,301 acres; that of 1879 was 472,661,157 pounds, grown on 638,841 acres, which shows an increase of about 9 per cent. in acreage and 4 per cent. in products. The average yield per acre for 1879 was 738·28 pounds; for 1889, 702·22 pounds. Tobacco is grown to a greater or less extent in nearly every State and territory, the only exceptions being the northern Rocky Mountain States: but it is a commercial product in only fifteen States, which together raise 98 per cent. of the crop of the country. These fifteen States are, in the order of the weight of the crop, Kentucky, Virginia, Pennsylvania, Ohio, Tennessee, North Carolina, Maryland, Connecticut, Missouri, Wisconsin, Indiana, New York, Massachusetts, Illinois, West Virginia. Two other States, Florida and Texas, are known to have produced some cigar tobacco since the last census was taken. In yield per acre Connecticut ranks first, with Massachusetts, Pennsylvania, New York, Wisconsin, Ohio, Missouri, and Kentucky following in the order named. In area cultivated Kentucky is first, Virginia second, North Carolina third, Tennessee fourth, Maryland fifth, Ohio sixth, Pennsylvania seventh, and Missouri eighth. There is a great difference in the annual yield per acre by weight in the different States, due not alone to the difference in soil and care in cultivation, but also to the varieties cultivated and to differences in the weather, to which the tobacco plant is extremely susceptible. Some of the lighter varieties are grown for beauty of colour and richness of flavour; other varieties are grown for bulk and weight. In the States having the highest yield per acre, the seed leaf varieties are principally grown and high manuring practised. In Ohio and Kentucky the hurly varieties are largely grown, which produce a large hulk. In North Carolina, on the other hand, the bright yellow variety is extensively raised, which gives a low yield per acre by weight. The following table (XXI.) contains statistics of tobacco production, exports, and imports, based upon information collected by the commissioner of internal revenue and the bureau of statistics of the Treasury Department. The tobacco manufactured is reported to the first-named office, and that imported and exported to the last. From these data it is possible to ascertain approximately the total crop of the country:—

TABLE XXI.—*Production of Tobacco in the United States,* 1892 *to* 1898, *as compiled from the Reports of the Bureau of Internal Revenue and of the Bureau of Statistics of the Treasury Department.*

	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Tobacco manufactured :							
Chewing, smoking, and snuff[1]	Pounds. 234,081,332	Pounds. 219,858,869	Pounds. 250,994,675	Pounds. 234,561,904	Pounds. 265,871,158	Pounds. 247,358,414	Pounds. 286,453,738
Cigars and cigarettes[1]	96,925,980	89,973,814	93,639,213	95,053,056	96,213,473	102,519,323	106,855,524
Exports, domestic[1]	277,258,871	304,797,808	293,637,217	300,047,687	281,074,422	269,966,833	346,823,677
Exports, foreign[1]	1,611,863	1,776,636	3,060,385	2,767,454	1,779,103	2,323,516	1,847,637
	609,878,046	646,407,127	641,331,490	632,430,101	644,938,156	622,168,086	741,980,576
Less imports[1]	22,093,270	24,899,175	31,355,899	20,258,704	12,848,743	11,307,830	17,107,839
	587,784,776	621,507,952	609,975,591	612,171,397	632,089,413	610,860,256	724,872,737

[1] For calendar year following.

The average amount of unmanufactured tobacco exported each year during the five years 1894-98 was 293,033,628 pounds, valued at $24,267,718. The exports averaged 45 per cent. of the crop.

SUGAR AND MOLASSES.

The product of sugar cane, sorghum, and maple sap in 1880 and 1890 was as follows:—

Sugar Cane.

	1880.	1890.	
Sugar	214,646,400	301,284,395	pounds.
Produced on	227,776	274,975	acres.
Molasses	16,573,273	25,409,228	gallons.

This is an increase of 20·72 per cent. in area under cultivation, of 40·36 per cent. in sugar, and 53·31 per cent. in merchantable molasses.

Sorghum.

	1880	1890.	
Sugar	12,792	...	pounds.
Molasses	28,441,202	24,235,219	gallons.

Maple Sap.

	1880.	1880.	
Sugar	36,576,071	32,952,927	pounds.
Molasses	1,796,048	2,258,376	gallons.

Cane sugar is confined almost entirely to lower Louisiana. Some cane is grown in the adjacent portions of Texas, and a little in Georgia and Florida. The following table shows the sugar product of Louisiana for the years 1895 to 1900 inclusive:—

	Tons of 2240 pounds.
1895-1896	237,720
1896-1897	282,009
1897-1898	310,447
1898-1899	245,511
1899-1900	132,000

The cane sugar of commerce has averaged 2,900,000 tons in round numbers during 1895-1900; of this all America and the West Indies produces 1,400,000 tons.

The production of sorghum molasses is about evenly distributed over the five States of Tennessee, Kentucky, Missouri, Illinois, and Iowa, with Nebraska and Kansas as the next most important. The maple sugar product is confined to the north-western and central States. The States yielding 2,000,000 pounds, or more, each of maple sugar, are Vermont, New York, Michigan, Ohio, Pennsylvania, and New Hampshire. In 1895 only 30,000 tons of sugar were made in the United States from beets in the States of California, Nebraska, and Utah. The Department of Agriculture has recently devoted considerable attention to the culture of sugar beets, with the result that 73,000 tons of sugar were produced in 1899-1900 in these and a few other States. The total cane and beet sugar production of the world, 1899-1900, as given hy the year-book of the Department of Agriculture, was 8,500,000 tons in round numbers. The United States produced 132,000 tons; Porto Rico, 50,000 tons; Cuba, 395,000 tons; the Hawaiian Islands, 275,000 tons; and the Philippine Islands (exports only), 40,000 tons, making a total of 892,000 tons for the United States and these islands.

AGRICULTURAL EDUCATION.

The agricultural schools of the United States owe their origin to the movement against the old classical school, and in favour of technical education which commenced in most civilized nations about the middle of the century. A rapidly growing country with great natural resources needed men educated in the sciences and arts of life, and this want was first manifested in the United States by a popular agitation on behalf of agricultural schools. A number of so-called agricultural schools were started between 1850 and 1860 in the eastern and middle States, where the movement made itself most felt, but without trained teachers and suitable methods they accomplished very little. They were only ordinary schools with farms attached. The first constitution of the State of Michigan, adopted in 1850, provided for an agricultural school, and this was the first one established in the United States. The General Assembly of the State of Pennsylvania incorporated the Farmers' High School, now the State College, in 1854. Maryland incorporated her agricultural college in 1856, and Massachusetts chartered a school of agriculture in the same year. The agitation, which finally reached Congress, led to the establishment of the so-called "land-grant," or agricultural colleges. The establishment of these colleges was due chiefly to the wisdom and foresight of Justin S. Morrill, for over forty years a Representative or Senator from the State of Vermont, who introduced the first Bill for their endowment in the House of Representatives on 14th December 1857, and saw the latest one approved by the President on 30th August 1890. Mr Morrill is justly known, therefore, as the father of the American agricultural colleges. The first Act for the benefit of these colleges was entitled "An Act donating public lands to the several states and territories which may provide colleges for the benefit of agriculture and the mechanic arts," and granted to each State an amount of land equal to 30,000 acres for each senator and representative in Congress to which the State was entitled at that time. The object of the grant was stated to be "the endowment, support, and maintenance of at least one college" (in each State), "where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." The total number of acres of land granted to the States under this Act was 9,359,241, of which 985,833 are still unsold. This grant has produced an endowment fund amounting to $10,262,944. The lands still unsold are valued at $4,062,850. The invested land-grant funds yield these colleges a total annual income of $624,673. Including the United States appropriation under a Supplementary Act of 1890, commonly known as the second Morrill Act, which now gives each college $25,000 a year, the interest on the land-grant and all other invested funds, all State appropriations and other sources of revenue, these colleges had in 1899 a total income of $5,995,000. Sixty-four institutions have been organized under this Act, of which sixty-one maintain courses in agriculture; nineteen are departments of agriculture and engineering in State universities; twenty-seven are separate colleges of agriculture and mechanic arts; and the remainder are organized in various other ways. Separate schools for persons of African descent have been established under this Act in eight southern States. These colleges take students prepared in the common schools and give them a course of from two to four years in the sciences pertaining to agriculture. Many of them offer short courses, varying from four to twelve weeks in length, in agriculture, horticulture, forestry, and dairying, which are largely attended. Agricultural experiment stations are connected with all the colleges, and many of them conduct farmers' institutes, farmers' reading clubs, and correspondence classes.

The agricultural *Experiment Stations* of the United States grew up in connexion with the agricultural colleges. Several of the colleges early attempted to establish separate departments for research and practical experiments, on the plan of the German stations. The Act establishing the Agricultural College of Maryland required it to conduct "a series of experiments upon the cultivation of cereals and other plants adapted to the latitude and climate of the State of Maryland." This was the first suggestion of an experiment station in America, but resulted in little. The first experiment station was established at Middletown, Connecticut, in 1875, in connexion with the agricultural branch of the Sheffield Scientific School of Yale College. The State of Connecticut made in 1877 an appropriation of $5000 to promote agriculture by scientific investigation and experiment—the first State appropriation for this purpose. The State of North Carolina established, on 12th March 1877, an agricultural experiment and fertilizer control station in connexion with its State university. The Cornell university experiment station was organized by that institution in 1879. The New Jersey station was organized in 1880, and the station of the University of Tennessee in 1882. From these beginnings the experiment stations multiplied until, when Congress passed the National Experiment Station Act in 1887, there were seventeen already in existence. The Hatch Experiment Station Act, so called from the fact that its leading advocate was Mr William H. Hatch of Missouri, appropriated $15,000 a year to each agricultural college for the purpose of conducting an agricultural experiment station. The object of the stations was declared to be, "to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural or artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective States or territories." The stations were authorized to publish annual reports and also bulletins of progress for free distribution to farmers. The franking privilege was given to these publications. The office of experiment stations, in the Department of Agriculture, was established in 1888 to be the head office and clearing-house of these stations. Agricultural experiment stations are now in operation in all the States and territories. Alabama, Connecticut, New Jersey, and New York each maintains a separate station, supported wholly or in part by State funds; and Louisiana has a station for sugar experiments. Excluding all branch stations, the total number of experiment stations in the United States is fifty-six, and of these fifty-two receive the national appropriation. The total income of the stations during 1899 was $1,143,335, of which $720,000 was received from the National Government and the remainder was derived from societies, fees for analyses of fertilizers, sale of products, &c. The stations employ 678 persons in the work of administration and research; the chief classes being—directors, 71; chemists, 150; agriculturists, 70; horticulturists, 80; botanists, 52; entomologists, 47; physicists, 7; bacteriologists, 20; dairymen, 25; weather observers, 17; irrigation experts, 5. During 1899 the stations published 450 annual reports and bulletins, besides a large number of "press" bulletins, which are reproduced in the agricultural and county papers. The stations are to a great extent bureaus of information on all farm questions, and carry on an extensive correspondence covering all conceivable questions. Their mailing lists aggregate half a million names.

AGRICULTURAL DEPARTMENT.

The United States Department of Agriculture was established as a result of a recommendation of President

Washington, though not until many years after his death. An office for distributing seeds and collecting agricultural statistics grew up in the patent office which was originally the only scientific agency of the government. This developed gradually into the present department, which became in 1889 an executive department of the government with a secretary. This secretary is now charged with the supervision of all business relating to the agricultural and productive industries. The fisheries have a separate bureau, and the public lands and mining interests are cared for in the interior department; but with these exceptions, all the productive interests are looked after by the Department of Agriculture. There are various bureaus in this department. The weather bureau has charge of the forecasting of weather; the issue of storm warnings; the display of weather and flood signals for the benefit of agriculture, commerce, and navigation; the gauging and reporting of rivers; the reporting of temperature and rainfall conditions for the cotton, rice, sugar, and other interests; the display of frost and cold waves signals; and the distribution of meteorological information in the interest of agriculture and commerce. The bureau of animal industry makes investigations as to the existence of contagious pleuro-pneumonia and other dangerous and communicable diseases of live stock, superintends the measures for their extirpation, makes original investigations as to the nature and prevention of such diseases, and reports on the conditions and means of improving the animal industries of the country. The division of statistics collects information as to the condition, prospects, and harvests of the principal crops, and of the number and status of farm animals. It records, tabulates, and co-ordinates statistics of agricultural production, distribution, and consumption, and issues monthly and annual crop reports for the information of producers and consumers. The section of foreign markets makes investigations and disseminates information "concerning the feasibility of extending the demands of foreign markets for the agricultural products of the United States." The office of experiment stations represents the department in its relations to the experiment stations which are now in operation in all the States and territories. The division of chemistry makes investigations of the methods proposed for the analyses of soils, fertilizers, and agricultural products, and such analyses as pertain in general to the interest of agriculture. The division of entomology obtains and disseminates information regarding insects injurious to vegetation. The biological survey studies the geographic distribution of animals and plants, and maps the natural life zones of the country; it also investigates the economic relations of birds and mammals, and recommends measures for the preservation of beneficial, and the destruction of injurious species. The division of forestry is occupied with experiments, investigations, and reports dealing with the subject of forestry, and with the dissemination of information upon forestry matters. The division of botany investigates botanical agricultural problems, including the purity and value of agricultural seeds, methods of controlling the spread of weeds or preventing their introduction into the country, &c. The division of vegetable physiology and pathology has for its object the study of the normal and abnormal life processes of plants. It seeks by investigation in the field and experiments in the laboratory to determine the causes of diseases and the best means of preventing the same. The division of agrostology is charged with the investigation of the natural history, geographical distribution, and use of grasses and forage plants, their adaptation to special soils and climates, and the introduction of native and foreign kinds into cultivation. The division of pomology collects and distributes information in regard to the fruit interest of the United States. The division of soil has for its object the investigation of the physical properties of the soils and their relation to crop production. The office of public road inquiries collects information concerning systems of road management, conducts investigations regarding the best method of road-making, and prepares publications on this subject. The division of seeds is charged with the purchase and distribution of valuable seeds, a certain portion of which are collected from foreign countries for experiments with reference to their introduction into the United States. They are distributed in allotments to senators, representatives, delegates in Congress, agricultural experiment stations, and by the Secretary of Agriculture, as provided by law.

The appropriations for the Department of Agriculture for the fiscal year ending 30th June 1899 aggregate $2,829,702, distributed in part as follows:—

Salaries	$319,300
Library	6,000
Museum	1,500
Animal quarantine stations	12,000
Collecting agricultural statistics	105,000
Botanical investigations and experiments	20,000
Entomological investigations	20,000
Vegetable pathological investigations	20,000
Biological investigations	17,500
Pomological investigations	9,500
Laboratory of chemistry	12,400
Forestry investigations	20,000
Experimental gardens and grounds	20,000
Soil investigations	10,000
Grass and forage plant investigations	10,000
Office of agricultural experiment stations in the department[1]	40,000
Nutrition investigation	15,000
Public road inquiries	8,000
Publications	65,000
Sugar investigations	7,000
Purchase and distribution of valuable seeds	130,000
Salaries and expenses, bureau of animal industry	900,000
Irrigation	10,000
Weather bureau	1,015,502

The balance is devoted to miscellaneous current expenses. (C. W. D.)

Aguadilla, a town on the west coast of Porto Rico, the capital of a province of the same name. It is surrounded by a fertile country producing sugar-cane, oranges, and lemons, and possesses a copious natural fountain, said to have been discovered by Columbus on his second voyage. It was founded in 1775. Population (1899), 6425.

Aguascalientes, a state of Mexico, bounded on the N., W., and E. by the state of Zacatecas, and on the S. by the state of Jalisco. Its area covers 2950 square miles. The population in 1879 was 140,430, and in 1895, 102,378. It is divided politically into four *partidos*, subdivided into eight municipalities. The fauna embraces twenty-seven species of mammals, fifty-eight of birds, nine of reptiles, five batrachians, four fishes, and seventy-four insects. The flora includes 137 species of wild trees, forty-eight of fruit, eleven textile plants, and 103 medicinal plants, &c. The principal industries are agriculture and stock-raising. The total value of the trade is estimated at about $7,500,000 (Mexican currency). The Mexican Central railway crosses the state in two directions. The capital, AGUASCALIENTES, with a population in 1895 of 30,872, is 364 miles from the city of Mexico by rail. It has two lines of tramways, telegraph and telephone lines, schools, hospitals, public libraries, &c. The other principal towns are Rincón de Romos (or Victoria de Calpulapam), Asientos de Ibarra, and Calvillo, all with populations of less than 5000.

---

[1] In addition to this amount which went to the support of the central bureau of experiment stations, $720,000 was paid directly to agricultural experiment stations in the States by the United States Treasury.

Aguilas, a town of Spain, province of Murcia, on the Mediterranean, 37 miles W.S.W. of Cartagena. It has two ports, one safe, the other bad. Its trade has become important, owing to the greater facilities now afforded for transport of ores by several lines of railways. In 1898, 74 foreign steamers of 70,372 tons (60 English of 58,372 tons) cleared from the port, and 120 Spanish steamers of 65,368 tons. The chief exports were: iron ore, 59,630 tons, of which 47,180 were for Great Britain; spart grass, 19,496 tons for Great Britain; and barley, soapstones, and dried figs. Population in 1897, 12,331.

Ahaggar. See SAHARA.

Ahmedabad, or AHMADABAD, a city and district of British India, in the Gujarat division of Bombay. The city is situated on the left bank of the river Sabarmati. It is still surrounded with walls, enclosing an area of about 2 square miles. Ahmedabad has a station on the Bombay and Baroda railway, 309 miles from Bombay, whence branch lines diverge into Kathiawar and Mahi Kantha, and is a great centre for both trade and manufacture. Its native bankers, shopkeepers, and workers are all strongly organized in guilds. In 1897 there were 16 cotton-mills, for spinning and weaving, besides many hand-looms, and 14 factories for ginning and pressing cotton. Other industries include the manufacture of gold and silver thread, silk brocades, pottery, paper, and shoes. The principal educational institutions are the Gujarat College, managed by a board, with 199 students in 1896-97; a government training college for both male and female teachers, with 219 students altogether; and a high school, with 365 boys. There are 2 churches, 22 printing presses, issuing 7 newspapers and periodicals, a hospital, a lunatic asylum, an asylum for lepers, and a *panjrapol* or home of rest for animals, supported by the trading community. The military cantonment, 3 miles north of the native town, is the headquarters of the northern division of the Bombay command, with an arsenal. Population (1881), 127,621; (1891), 148,412.

The district of AHMEDABAD lies at the head of the Gulf of Cambay, between Baroda and Kathiawar. Area, 3949 square miles; population (1881), 856,342; (1891), 921,712, showing an increase of 8 per cent. and an average density of 233 persons per square mile; in 1901 the population was 795,094, showing a decrease of 14 per cent., due to the results of famine. Land revenue and rates (1897-98) amounted to Rs.23,63,780, the incidence of taxation being R.1:1:0 per acre; the cultivated area was 1,151,117 acres, of which 69,149 acres were irrigated from wells, &c., including 6142 acres from government canals; the number of police was 1098; the number of children at school was 28,795, being 3·56 per cent. of the total population; the registered death-rate in 1897 was 25·37 per thousand. The principal crops are millets, cotton, wheat, and pulse. The district is traversed by the Bombay and Baroda railway, and has two seaports, Dholera and Gogo, the former of which has given its name to a mark of raw cotton in the Liverpool market. It suffered severely in the famine of 1899-1900.

Ahmednagar, a city and district of British India, in the Deccan division of Bombay, on the left bank of the river Sina. Several mosques and tombs have been converted to the use of British administration. The old industries of carpet-weaving and paper-making have died out; but there is a large trade in cotton and silk goods, and in copper and brass pots, and there are 9 factories for ginning and pressing cotton. It is a station on the loop line of the Great Indian Peninsula railway, 218 miles from Bombay, and a military cantonment for a native infantry regiment. It has three high schools, with 435 pupils in 1896-97, and 7 printing presses, issuing 6 vernacular newspapers. Population (1881), 37,492; (1891), 41,689.

The district of AHMEDNAGAR is a comparatively hilly and barren tract, with a small rainfall. Area, 6645 square miles; population (1881), 750,021; (1891), 888,755, showing an increase of 18 per cent. after the famine of 1876-77; average density, 134 persons per square mile; (1901), 837,774, showing a decrease of 6 per cent., due to the results of famine. In 1897-98 the land revenue and rates were Rs.19,07,825, the incidence of assessment being Rs.2:1:2 per acre; the cultivated area was 2,585,616 acres, of which 110,246 were irrigated from wells, &c.; the number of police was 807; the children at school numbered 15,569, being 1·8 per cent. of the total population; the death-rate in 1897 was 43 per thousand. The principal crops are millets, pulse, oil-seeds, and wheat. The district suffered from drought in 1896-97, and again in 1899-1900. Down to July 1898 the deaths from plague numbered 852.

Ahmed Vefik, PASHA, (1819-1891), Turkish statesman and man of letters, was born in Stambul, 1819. He was the son of Rouheddin Effendi, at one time Chargé d'affaires in Paris, an accomplished French scholar, who because of this accomplishment was attached in the capacity of secretary-interpreter to Reshid Pasha's diplomatic mission to Paris in 1834. Reshid took Ahmed with him, and placed him at school, where he remained about five years and completed his studies. He then returned to Constantinople, and was appointed to a post in the *Bureau de traduction* of the ministry for foreign affairs. While thus employed he devoted his leisure to the translation of Molière's plays into Turkish, and to the compilation of educational books—dictionaries, historical and geographical manuals, &c.—for use in Turkish schools, with the object of promoting cultivation of the French language among the rising generation. In 1847 he brought out the first edition of the *Salnameh*, the official annual of the Ottoman empire, of which the publication is continued to this day. Two years later he was appointed imperial commissioner in the Danubian principalities, and held that office till early in 1851 when he was sent to Persia as ambassador—a post which suited his temperament, and in which he rendered good service to his Government for more than four years. Recalled in 1855, he was sent on a mission to inspect the eastern frontiers, and on his return was appointed member of the Grand Council of Justice, and was entrusted with the revision of the penal code and the code of procedure. This work occupied him until the beginning of 1860, when he was sent as ambassador to Paris, for the special purpose of averting the much-dreaded intervention of France in the affairs of Syria. But Ahmed Vefik's abrupt frankness, irascibility, and abhorrence of compromise unfitted him for European diplomacy. He offended the French Government; his mission failed; and he was recalled in January 1861. None the less his integrity of purpose was fully understood and appreciated in Paris. On his return he was appointed minister of the *Evkaf*, but he only retained his seat in the Cabinet for a few months. He was then for a brief period president of the Board of Audit, and subsequently inspector of the

Anatolian provinces where he was engaged for more than three years. His next appointment was that of director-general of customs, whence he was removed to the office of musteshar of the grand vizierate, and in the following year entered the Cabinet of Midhat Pasha as minister of public instruction, but very soon retired to his seat in the Council of State, and remained out of office until 1875 when he represented Turkey at the International Telegraphic Conference in St Petersburg. He was president of the short-lived Turkish parliament during its first session—19th March to 28th June 1877—and at its close was appointed vali of Adrianople, where he rendered invaluable aid to the Red Cross Society. On his recall at the beginning of 1878 he accepted the ministry of public instruction in the Cabinet of Ahmed Hamdi Pasha, and on the abolition of the grand vizierate (5th February 1878) he became prime minister, and held office till about the middle of April, when he resigned. Early in the following year he was appointed vali of Brusa, where he remained nearly four years, and rendered admirable services to the province. The drainage of the pestilent marshes, the water-supply from the mountains, the numerous roads, the suppression of brigandage, the multiplication of schools, the vast development of the silk industry through the substitution of mulberry plantations for rice fields, the opening out of the mineral springs of Tchitli, the introduction of rose-trees, and the production of otto of roses—all these were Ahmed Vefik's work; and he became so popular that when in 1882 he was recalled, it was thought advisable that he should be taken away secretly by night from the *konak* in Brusa, and brought to his private residence on the Bosphorus. A few days after his return he was again appointed prime minister (1st December 1882), but Ahmed Vefik demanded, as the condition of his acceptance of office, that he should choose the other members of the Cabinet, and that a number of persons in the sultan's *entourage* should be dismissed. Upon this, the sultan, on 3rd December, revoked the iradé of 1st December, and appointed Said Pasha prime minister. For the rest of his life Ahmed Vefik, by the sultan's orders, was practically a prisoner in his own house; and eventually he died, 1st April 1891, of a renal complaint from which he had long been a sufferer. Ahmed Vefik was a great linguist. He spoke and wrote French perfectly, and thoroughly understood English, German, Italian, Greek, Arabic, and Persian. From all these languages he translated many books into Turkish, but wrote no original work. His splendid library of 15,000 volumes contained priceless manuscripts in many languages. In his lifetime he appreciably aided the progress of education; but, as he had no following, the effects of his labour and influence in a great measure faded away after his death. In all his social and family relations Ahmed Vefik was most exemplary. His charity knew no bounds. He was devoted to his aged mother and to his one wife and children. To his friends and acquaintances he was hospitable, courteous, and obliging; his conversation was intellectual and refined, and in every act of his private life he manifested the spirit of a true gentleman. At home his habits, attire, and mode of life were quite Turkish, but he was perfectly at his ease in European society; he had strong English proclivities, and numbered many English men and women amongst his intimate friends. In public life his gifts were almost sterilized by peculiarities of temperament and incompatibility with official surroundings; and his mission as ambassador to Persia and his administration of Brusa were his only thorough successes. But his intellectual powers, literary erudition, and noble character made him for the last forty years of his life a conspicuous figure in Eastern Europe.

(E. W.*)

Ahvaz, a town in the province of Arabistan, Persia, situated on the left bank of the river Karun, has been identified with the Aginis of Nearch. It is now a wretched collection of mud hovels, with a small rectangular fort in a state of ruin, and an Arab population of about 700. Since the opening of the Karun to foreign commerce in October 1888 another settlement called *Bander i Nássiri*, in compliment to the shah (Nássir ed dín), has been established on a slight elevation overlooking the river at the point near the rapids, where steamers come to anchor, and about one mile below Ahvaz. It has post and telegraph offices, and a few mercantile firms have established agencies at Bander Nássiri. Should the new caravan road to Isfahan prove a success, Ahvaz will no doubt soon acquire greater commercial importance.

Aidin, (1) a Turkish viláyet, in the S.W. part of Asia Minor, which includes the ancient Lydia, Caria, and Western Lycia. It derives its name from the Seljúk emir who took Tralles, and is the richest and most productive province of Asiatic Turkey. The seat of government is Smyrna. Population, 1,400,000 (Moslem, 1,090,000; Christians, 288,000; Jews, 22,000). (2) The principal town of the rich, productive valley of the Menderez, called also Güzel-hissar from the beauty of its situation at the foot and on the lower slopes of *Mons Messogis*. Aidin is on the Smyrna-Dineir railway, has large tanneries, and sweetmeat manufactories, and exports figs, cotton, and raisins. It was almost destroyed by an earthquake in 1899. It is the seat of a British vice-consul. Population, 34,000 (Moslems, 23,000; Christians, 9000; Jews, 2000).

Aigun, or AIHUN (also *Sakhalyan-ula-khoto*), a town of China, province Hei-lun-tsian, in Northern Manchuria, situated on the right bank of the Amur, in a fertile and populous region, 20 miles below Blagovyeshchensk, where it occupies nearly two miles on the bank of the river. There is a palisaded fort in the middle of the town, inside of which is the house of the *fu-tu-fun* (governor). Its merchants carry on an active local trade in grain, mustard, oil, and tobacco, and some of its firms supply the Russian administration with grain and flour. During the "Boxer" rising of 1900 it was, for a few weeks, the centre of military action directed against the Russians. The population, of some 20,000, includes a few hundred Mussulmans. The town was founded first on the left bank of the Amur, below the mouth of the Zeya, but was abandoned, and the present town was founded in 1684. It was here that Count Muravieff concluded, in May 1857, the Aihun treaty, according to which the left bank of the Amur was conceded to Russia.

Ain, a department in the E. of France, bordering on Switzerland. Its eastern part is traversed by the southern end of the Jura. The Rhône enfolds it on the E. and S., the Saône forms its western border; the Ain runs through its centre from N. to S. into the Rhône. Among the lacustrine formations is Lake Nantua. The chief towns are Bourg, Belley, Gex, Nantua, and Trévoux.

Area, 2219 square miles. The department comprises 36 cantons and 463 communes. Population in 1901, 349,205, against 351,569 in 1896 and 364,408 in 1886. Births in 1899, 7204, of which 362 were illegitimate; deaths, 7204; marriages, 2665. In 1896 there were 1063 primary schools, with 57,502 pupils. Less than 1 per cent. of the population was illiterate. The total surface under cultivation was 1,236,173 acres, of which 601,744 acres were plough-land; 229,786 acres in grass, and 265,772 acres in forest. In 1899 the produce of wheat amounted to the value of £1,025,000; of wine, £405,000. There were (1899) 14,200 horses, 3080 asses and mules, 210,190 cattle, 50,720 sheep, 87,030 pigs, and 20,190 goats. The mineral production (lignite, peat, and other substances) is unimportant. There is no industry in metals. With agriculture, the industries in weaving, wearing apparel, foods, and the manufacture of paper, are the sources of the prosperity of Ain.

Ainsworth, William Harrison (1805-1882), English novelist, son of Thomas Ainsworth, solicitor, was born at Manchester, 4th February 1805. He was educated at Manchester Grammar School, and articled to the firm of which his father was a member, proceeding to London in 1824 to complete his legal training at the Inner Temple. At the age of twenty-one he married a daughter of John Ebers, the publisher, and started in his father-in-law's line of business. This, however, soon proved unprofitable, and he decided to attempt literary work. A novel called *Sir John Chiverton*, in which he appears to have had a share, had attracted the praise of Sir Walter Scott, and this encouragement decided him to take up fiction as a career. In 1834 he published *Rookwood*, which had an immediate success, and thenceforth he was always occupied with the compilation of "historical" novels. He published about forty such stories, of which the best known are *Jack Sheppard* (1839), *The Tower of London* (1840), *Guy Fawkes* (1841), *Old St Paul's* (1841), and *Windsor Castle* (1843). He edited *Bentley's Miscellany*, in which *Jack Sheppard* was published as a serial, and for twelve years from 1842 he was proprietor of *Ainsworth's Magazine*. He continued his literary activity until his death, but his later stories were less striking than the earlier, perhaps owing to his having exhausted the more fruitful fields of historical narrative in his first flights. He died at Reigate, 3rd January 1882, and was buried at Kensal Green. Ainsworth had a lively talent for plot, and his books have many attractive qualities. He was skilful in weaving historical facts into the fabric of fiction, and in giving just sufficient of the former to leaven the latter with an air of probability. His style was not without archaic affectation and awkwardness, but when his energies were aroused by a striking situation he could be brisk, vigorous, and impressive. He did a great deal to interest the less educated classes in the historical romances of their country, and his tales were invariably instructive, clean, and manly. (A. WA.)

Aintab, mediæval *Hamtab*, a large garrison town in Syria, in the Aleppo vilâyet, situated in the broad valley of the Sajûr. Its position is one of military and commercial importance, and its castle was noted in the Middle Ages for its great strength. In 1895 many Armenians were massacred and the bazârs were pillaged. American missionary and educational enterprise has established Central Turkey College, with a medical school, a girls' school, and an hospital. Cereals and tobacco are exported, and cotton cloths are made. Population, 45,000 (Moslems, 26,000; Christians, 18,500; Jews, 500).

Ainu.—The Ainu—often erroneously called Aino—are usually spoken of as the autochthonous inhabitants of Japan, but the most accurate researches go to prove that they were immigrants, who reached Yezo from the Kuriles, and subsequently crossing Tsugaru strait, colonized a great part of the main island of Japan, exterminating a race of pit-dwellers to whom they gave the name of *koro-pok-guru* (men with sunken places). These *koro-pok-guru* were of such small stature as to be considered dwarfs. They wore skins of animals for clothing, and that they understood the potter's art and used flint arrow-heads is clearly proved by excavations at the sites of their pits. The Ainu, on the contrary, never had any knowledge of pottery. Ultimately the Ainu, coming into contact with the Japanese, who had immigrated from the south and west, were driven northward into the island of Yezo, where, as well as in the Kuriles and in the southern part of Saghalien, they are still found in some numbers. When, at the close of the 18th and the beginning of the 19th century, Russian enterprises drew the attention of the Japanese Government to the northern districts of the empire, the Tokugawa Shoguns adopted towards the Ainu a policy of liberality and leniency consistent with the best principles of modern colonization. But the doom of unfitness appears to have begun to overtake the race long ago. History indicates that in ancient times they were fierce fighters, able to offer a stout resistance to the incomparably better armed and more civilized Japanese. To-day, they are drunken, dirty, spiritless folk, whom it is difficult to suppose capable of the warlike *rôle* they once played. Their number is virtually stationary, as the census shows:—

Ainu Population of Yezo and the Kuriles.

1893	17,280
1894	15,308
1895	17,314
1896	17,400
1897	16,972
1898	17,573

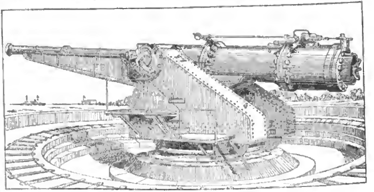
The Ainu are somewhat taller than the Japanese, stoutly built, well proportioned; with dark-brown eyes, high cheek-bones, short broad noses and faces lacking length. Naturally very hairy and never shaving after a certain age, they have full beards and moustaches. Men and women alike cut their hair level with the shoulders at the sides of the head, but trim it semicircularly behind. The women tattoo their mouths, arms, and sometimes their foreheads, using for colour the smut deposited on a pot hung over a fire of birch bark. Their original dress is a robe spun from the bark of the elm tree. It has long sleeves, reaches nearly to the feet, is folded round the body and tied with a girdle of the same material. Females wear also an undergarment of Japanese cloth. In winter, the skins of animals are worn, with leggings of deer-skin and boots made from the skin of dogs or salmon. Both sexes are fond of ear-rings, which are said to have been made of grape-vine in former times, but are now purchased from the Japanese, as also are bead necklaces, which the women prize highly. Their food is meat, whenever they can procure it—the flesh of the bear, the fox, the wolf, the badger, the ox, or the horse—fish, fowl, millet, vegetables, herbs, and roots. They never eat raw fish or flesh, but always either boil or roast it. Their habitations are reed-thatched huts, the largest 20 feet square, without partitions and having a fireplace in the centre. There is no chimney, but only a hole at the angle of the roof; there is one window on the eastern side and there are two doors. Public buildings do not exist, whether in the shape of inn, meeting-place, or temple. The furniture of their dwellings is exceedingly scanty. They have no chairs, stools, or tables, but sit on the floor, which is covered with two layers of mats, one of rush, the other of flag; and for beds they spread planks, hanging mats around them on poles, and employing skins for coverlets. The men use chop-sticks and moustache-lifters when eating; the women have wooden spoons. Uncleanliness is characteristic of the Ainu, and all their intercourse with the Japanese has not improved them in that respect. The Rev. Mr Batchelor, in his *Notes on the Ainu*, says that he lived in one Ainu habitation for six weeks on one occasion, and for two months on another, and that he never once saw personal ablutions performed, or cooking or eating utensils washed. Not having been at any period acquainted with the art of writing, they have no literature and are profoundly ignorant. But at schools established for them by the Japanese in recent times, they have shown that their intellectual capacity is not deficient. No distinct conception of a universe enters into their cosmology. They picture to themselves many floating worlds, yet they deduce the idea of rotundity from the course of the sun, and they imagine that the "Ainu world" rests on the back of a fish whose movements cause earthquakes. It is scarcely possible to doubt that this fancy is derived from the Japanese, who used to hold an identical theory. They believe in a supreme Creator, but also in a sun god, a moon god, a bear god, a water god, and a mountain god; deities whose river is the Milky Way, whose voices are heard in the thunder and whose glory is reflected in the lightning. They have no priests by profession. The village chief performs whatever religious ceremonies are necessary; ceremonies confined to making libations of wine, uttering short prayers and offering willow sticks with wooden shavings attached to them, much as the Japanese set up the well-known *gohei* at sacred spots. The Ainu gives thanks to the gods before eating, and prays to the deity of fire in time of sickness. He thinks that his spirit is immortal, and that it will be rewarded hereafter in heaven or punished in hell, both of which places are beneath the earth, hell being the land of volcanoes; but he has no theory as to a resurrection of the body or metempsychosis. He preserves a tradition about a flood which seems to be the counterpart of the Biblical deluge, and about an earthquake which lasted a hundred days, produced the three volcanoes of Ezo, and created the island by bridging the waters that had previously separated it into two parts. He is now governed by Japanese laws and judged by Japanese tribunals, but in former times his affairs were administered by hereditary chiefs, three in each village, and for administrative purposes the country was divided into three districts, Sara, Usu, and Ishikari, which were under the ultimate control of Sara, though the relations between their respective inhabitants were not close and intermarriages were avoided. The functions of judge were not entrusted to these chiefs; an indefinite number of a community's members sat in judgment upon its criminals. Capital punishment did not exist, nor was imprisonment resorted to, beating being considered a sufficient and final penalty, except in the case of murder, when the nose and ears of the assassin were cut off or the tendons of his feet severed. These peculiar methods of criminal procedure are alluded to by ancient Japanese historians, who appear to have regarded them as more barbarous than infliction of the death penalty.

Little as the Japanese and the Ainu have in common, intermarriages are not infrequent, and at Sambutsu especially, on the eastern coast, many children of such marriages may be seen. Doenitz, Hilgendorf, and Scheube, arguing from a minute investigation of the physical traits of the Ainu, have concluded that they are "Mongolians who differ less, perhaps, from the Japanese than the Germans do from the Rumanians," but if their customs, traditions, and religious beliefs be considered, the points of dissimilarity are very striking. According to Professor A. H. Keane, the Ainu "are quite distinct from the surrounding Mongolic peoples, and present several remarkable physical characters which seem to point to a remote connexion with the Caucasic races. Such are a very full beard, shaggy or wavy black or dark-brown hair, sometimes covering the back and chest; a somewhat fair or even white complexion, large nose, straight eyes, and regular features, often quite handsome, and of European type. They seem to be a last remnant of the Neolithic peoples, who ranged in prehistoric times across the northern hemisphere from the British Isles to Manchuria and Japan. They are bear-worshippers, and have other customs in common with the Manchurian aborigines, but the language is entirely different, and they have traditions of a time when they were the dominant people in the surrounding lands." It should be noted finally that the Ainu are altogether free from ferocity or exclusiveness, and that they treat strangers with gentle kindness. (F. BR.)

Airdrie, a parliamentary and municipal burgh (Falkirk group) in new Monkland parish, Lanarkshire, Scotland, 10 miles E. of Glasgow by rail. There are 35 coal mines in the parish, but the seams are now largely worked out. Brass-founding, steel-casting, tube-making, boiler-making, wagon-building, the weaving of woollens, calico-printing, paper-making, and oil and fire-clay manufacture, are now important, while several new branches of engineering have been started. There is a good free library. One of the board schools is an academy or secondary school. Population in 1881, 13,363; 1891, 19,135; 1901, 22,288.

Air Gun.—Air as a propellant has in recent years been applied to guns of large calibre, in which its comparatively gentle action has proved advantageous when high explosives contained in their shells are employed as projectiles. In 1883 Mr. Mefford of Ohio utilized an air pressure of 500 ℔ per square inch in a 2-inch gun, and succeeded in propelling a projectile 2100 yards. The arrangement was of the simplest form—a hose with an ordinary cock by which the air was admitted into the gun behind the projectile. The question was then taken up by Captain E. L. Zalinski of the United States Artillery, who in 1888 reduced the so-called "dynamite gun" to a practical shape and obtained excellent firing results.

The principal features of his system are:—1. An extremely ingenious balanced valve admitting the air pressure into the gun. This valve is opened and closed by a simple movement of the firing lever, and is capable of adjustment so that the propelling force, and consequently the range, can be regulated. 2. A light steel projectile carrying the bursting charge, and provided with a tail to which vanes are attached in order to give rotation. 3. Electric fuses of entirely original design. Each shell carries a wet battery, the current from which fires the charge on impact with any solid object, and a dry battery which becomes active after the shell has dived below the surface of the water, and ignites the charge after delay capable of regulation. For safety all the electric circuits are made to pass through a disconnector, which prevents them from being completed until the shell has been fired. The gun is a built-up



DYNAMITE GUN MOUNTED AT SANDY HOOK, NEW YORK HARBOUR.

smooth-bore tube, 15 inches or less in diameter. The full-calibre shell weighs 1000 ℔, and carries a bursting charge of 600 ℔ of blasting gelatine, cut into the form of cheeses, fitting the steel envelope, and provided with a core of dry gun-cotton as a primer. Sub-calibre projectiles, 10 in. and 8 in., can also be used. In their case, rotation is given by vanes or fins attached to the body of the shell. Air at 1000 ℔ pressure is stored in tubes close to the gun, and is supplied from primary reservoirs, to which it is directly pumped at a pressure of about 2000 ℔. There is always, therefore, a considerable reserve of power available without pumping. Pneumatic guns of this description (see figure) have been mounted for the protection of New York and San Francisco. With a full-calibre shell (1000 ℔) these guns have a range of 2400 yards; with a sub-calibre 8-in. shell (250 ℔) the maximum range is 6000 yards. The official trials showed remarkable accuracy. At 5000 yards 75 per cent. of the projectiles fell in an area of 360 × 90 feet. When the gun was tried at Shoeburyness the accuracy was far greater than could be obtained with howitzer shells propelled by explosives. On account of the power of exploding the shell under water, and thus securing a torpedo action, a direct hit upon a ship is not required, and the target offered is largely in excess of the deck plan. The gun is, in fact, capable of replacing systems of submarine mines with economy, and without the great objection of interfering with a waterway.

The only employment of the dynamite gun afloat has been in the case of the U.S.A. gunboat *Vesuvius*, which carries three in the bows. These guns are fixed at a constant angle of elevation, and the range is regulated by the air valve, training being given by the helm. Thus mounted on an unstable platform, the accuracy of fire obtainable must evidently be much less than on shore. The *Vesuvius* was employed during the Spanish-American war of 1898, when on several nights in succession she approached the defences of Santiago under cover of darkness and discharged three projectiles. Fire delivered under such conditions could not be sufficiently accurate to injure coast defences; but the shells burst well, and made large craters. (G. S. C.)

Airy, Sir George Biddell (1801-1892), British Astronomer Royal, was born at Alnwick on 27th July 1801. He came of a long line of Airys who traced their descent back to a family of the same name residing at Kentmere, in Westmoreland, in the 14th century, but the branch to which he belonged, having suffered in the civil wars, removed to Lincolnshire, where for several generations they lived as farmers. George Airy was educated first at elementary schools in Hereford, and afterwards at Colchester Grammar School. In 1819 he entered Trinity College, Cambridge, as a sizar. Here he had a most brilliant career, and seems to have been almost immediately recognized as the leading man of his year. In 1822 he was elected scholar of Trinity, and in the following year he graduated as senior wrangler and obtained first Smith's prize. On 1st October 1824 he was elected fellow of Trinity, and in December 1826 was appointed Lucasian Professor of Mathematics in succession to Turton. This chair he held for little more than a year, being elected in February 1828 as Plumian Professor of Astronomy and director of the new Cambridge observatory. Some idea of his activity as a writer on mathematical and physical subjects during these early years may be gathered from the fact that previous to this appointment he had contributed no less than three important memoirs to the *Philosophical Transactions of the Royal Society*, and eight to the Cambridge Philosophical Society. At the Cambridge observatory Airy soon gave evidence of his remarkable power of organization. At the time of his appointment the only telescope erected in the observatory was the transit instrument, and to this he devoted himself with vigour. By the introduction of a regular system of selection and arrangement of his observations, and a carefully worked out plan of reduction, he was able to keep his observations reduced practically up to date and published annually with a degree of punctuality which astonished his contemporaries. Under his direction a mural circle was soon erected, and regular observations were instituted with it in 1833. In the same year the duke of Northumberland presented the Cambridge observatory with a fine object glass of 12 inches' aperture, which was mounted according to Airy's designs and under his superintendence, although the erection was not completed until after his removal to Greenwich in 1835. Airy's writings during this time are divided between mathematical physics and astronomy. The former are for the most part concerned with questions relating to the theory of light, arising out of his professorial lectures, among which may be specially mentioned his paper "On the Diffraction of an Object-Glass with Circular Aperture." In 1831 the Copley medal of the Royal Society was awarded to him for these researches in optics. Of his astronomical writings during this period the most important are his investigation of the mass of Jupiter, his report to the British Association on the progress of astronomy during the 19th century, and his memoir *On an Inequality of Long Period in the Motions of the Earth and Venus*. His report is remarkable for the conciseness and accuracy with which the condition of the science at the time is exhibited. The last section but one of this report is devoted to "A Comparison of the Progress of Astronomy in England with that in other Countries," very much to the disadvantage of England. This reproach was subsequently, to a great extent, removed by his own labours.

Airy's discovery of a new inequality in the motions of Venus and the earth is in some respects his most remarkable achievement. In correcting the elements of Delambre's solar tables he had been led to suspect an inequality not embraced by those tables. For the cause of this he did not long seek in vain. Eight times the mean motion of Venus is so nearly equal to thirteen times that of the earth that the difference amounts to only the 1/240th of the earth's mean motion, and from the fact that the term depending on this difference, although very small in itself, receives in the integration of the differential equations a multiplier of about 2,200,000, Airy was led to infer the existence of a sensible inequality extending over 239 years. The investigation by which this result was established was probably the most laborious that had been made up to Airy's time in the planetary theory, and was the first specific improvement in the solar tables made in England since the establishment of the theory of gravitation. In recognition of this work the medal of the Royal Astronomical Society was awarded to him in 1833.

In June 1835 Airy was appointed Astronomer Royal in succession to Pond, and thus commenced that long career of wisely directed and vigorously sustained industry at the National Observatory which, even more perhaps than his investigations in abstract science or theoretical astronomy, constitutes his chief title to fame. The state of the observatory at the time of his appointment was such that Lord Auckland, the first lord of the Admiralty, considered that "it ought to be cleared out," while Airy admits that it "was in a queer state." With his usual energy he set to work at once to reorganize the whole management. He remodelled the volumes of observations, the library was put on a proper footing, the new (Sheepshanks) equatorial was erected, and a new magnetic observatory was built. In 1847 the altazimuth, designed by Airy to enable observations of the moon to be made whenever she might be visible (and not only on the meridian), was constructed. In 1848 Airy invented the reflex zenith tube to take the place of the zenith sector which had been employed up to that time. At the end of 1850 the great transit circle of 8 in. aperture and 11 ft. 6 in. focal length was erected; this telescope is still the principal instrument of its class at the observatory. And finally, in 1859, a large equatorial of 13 in. aperture was erected. In his journal for that year he remarks, "There is not now a single person employed or instrument used in the observatory which was there in Mr. Pond's time."

The great work of reducing the accumulated planetary observations made at Greenwich from 1750 to 1830 had been already commenced and was in progress when Airy became Astronomer Royal. Shortly afterwards he undertook the further laborious task of reducing the enormous mass of observations of the moon made at Greenwich during the same period under the direction, successively, of Bradley, Bliss, Maskelyne, and Pond, to defray the expense of which a large sum of money was allotted by the Treasury. The immediate result of this work, which was not completed till 1846, was to rescue from oblivion no less than 8000 observations of the moon, and to place them at the disposal of astronomers in such a form that they could be used directly for comparison with the theory and for the improvement of the tables of the moon's motion. For this work Airy received a testimonial from the Royal Astronomical Society in 1848. The first-fruit of this work was soon seen in the discovery by Prof. Hansen, of Seeburg in Gotha, of two new inequalities in the moon's motion. After completing this labour, and before engaging in any theoretical investigation in connexion with it, Airy made inquiries whether any other mathematician was pursuing the same subject, and learning that Prof. Hansen had undertaken this problem under the patronage of the king of Denmark, but that, owing to the death of the king, it was in danger of falling through for lack of funds, he applied to the Admiralty for the sum required to enable Prof. Hansen to complete his work. This request was immediately granted, and thus it comes about that Hansen's famous *Tables de la Lune* are dedicated to *La Haute Amirauté de sa Majesté la Reine de la Grande Bretagne et d'Irlande*.

One of the most remarkable of Airy's researches is his determination of the mean density of the earth. In 1826 the idea occurred to him of attacking this problem by means of pendulum experiments at the top and bottom of a deep mine. His first attempt, made in the same year, at the Dolcoath mine in Cornwall, failed in consequence of an accident to one of the pendulums; a second attempt in 1828 was defeated by a flooding of the mine, and many years elapsed before another opportunity presented itself. The experiments eventually took place at the Harton pit near South Shields in 1854. The immediate result of the experiment was to show that gravity at the bottom of the mine exceeded that at the top by 1/19286th of its amount, the depth being 1256 feet. From this he was led to the final value of 6·566 for the mean density of the earth as compared with that of water. This value is considerably in excess of that previously found by other methods, but from the care and completeness with which the observations were carried out and discussed, it is, as Airy himself says, "entitled to compete with the others on, at least, equal terms."

In 1872 Airy conceived the idea of treating the lunar theory in a new way, and at the age of seventy-one he embarked on the prodigious labour which this scheme entailed. A general description of his method will be found in the *Monthly Notices of the Royal Astronomical Society*, vol. xxxiv. No. 3. His method consisted essentially in the adoption of Delaunay's final numerical expressions for longitude, latitude, and parallax, with a symbolic term attached to each number, the value of which was to be determined by substitution in the equations of motion. In this mode of treating the question the order of the terms is numerical, and though the amount of labour is such as might well have deterred a younger man, yet the details were easy, and a great part of it might be entrusted to a mere computer. This work was published in 1886, when its author was eighty-five years of age. For some little time previously he had been harassed by a suspicion that certain errors had crept into the computations, and accordingly he addressed himself to the task of revising his work. But his powers were no longer what they had been, and he was never able to examine sufficiently into the matter. In 1890 he tells us how a grievous error had been committed in one of the first steps, and pathetically adds, "My spirit in the work was broken, and I have never heartily proceeded with it since." In 1881 Sir George Airy resigned the office of Astronomer Royal and resided at the White House, Greenwich, not far from the Royal Observatory, until his death, which took place on 2nd January 1892.

A complete list of Airy's printed papers, numbering no less than 518, will be found in his *Autobiography*, edited by his son, Wilfrid Airy, B.A., M.Inst.C.E. Amongst the most important of his works not already mentioned may be named the following:—*Mathematical Tracts* (1826) *on the Lunar Theory, Figure of the Earth, Precession and Nutation*, and *Calculus of Variations*, to which, in the second edition of 1828, were added tracts on the Planetary Theory, and the Undulatory Theory of Light; *Experiments on Iron-built Ships, instituted for the purpose of discovering a correction for the deviation of the Compass produced by the Iron of the Ships* (1839); *On the Theoretical Explanation of an apparent new Polarity in Light* (1840); *Tides and Waves* (1842).

He was elected a fellow of the Royal Society in 1836 and president in 1871, and received both the Copley and Royal medals. He was five times president of the Royal Astronomical Society, was correspondent of the French Academy, and belonged to many other foreign and American societies. He was D.C.L. of Oxford, and LL.D. of Cambridge and Edinburgh. In 1872 he was made K.C.B. In the same year he was nominated a Grand Cross in the Imperial Order of the Rose of Brazil; he also held the Prussian Order "Pour le Mérite," and belonged to the Legion of Honour of France, and to the Order of the North Star of Sweden and Norway. (A. A. R.*)

Aisne, a department in the N.E. of France. The northern part is crossed by branches of the Ardennes. The country is watered by the Somme, the Escaut, the Sambre, the Oise, tha Aisne, and the Marne.

Area, 2868 square miles. The department comprises 87 cantons and 841 communes, and its population in 1901 numbered 535,583, against 555,925 in 1886. The chief towns are Laon, the capital of the department, Château-Thierry, St Quentin, with important industries and 48,868 inhabitants in 1896, Soissons, and Vervins. Births in 1899, 12,164, of which 1450 were illegitimate; deaths, 12,077; marriages, 4251. In 1896 there were 1363 primary schools, with 76,645 pupils. Eight per cent. of the population was illiterate. Agriculture is highly developed, 1,717,107 acres being under cultivation in 1896, of which 1,197,950 acres were plough-land, 210,274 acres forest, and 197,688 acres in grass. In 1899 the produce of wheat was valued at £1,960,120; rye at £176,000; oats at £983,240. The production of mangold-wurzel and of potatoes is also considerable. The production of beetroot (1899) exceeded 26,000,000 hundredweights, placing the department second in this respect. The live stock numbered (1899) 781,060, of which 77,570 were horses. The value of milk products in 1899 was £1,012,000. There are no metals in the department of Aisne, but there is abundance of building-stone and of brick-clay. The industries of Aisne are weaving, St Quentin being renowned for its cambrics; plate-glass manufacture (St Gobain); glass-making (Folembray); but especially sugar-refining. With a production in 1899 of 171,000 tons, involving the labour of 10,500 men and women, Aisne takes the lead of all the departments of France in the sugar industry.

Aitaluki. See COOK ISLANDS.

Aivali, a prosperous town on the west coast of Asia Minor, opposite the island of Mitylene. It stands, near the site of the Æolian *Heracleia*, on rising ground at the end of a bay which is separated from the Gulf of Adramyttium, and protected from the prevailing winds by the Muskonesi Islands (*Hecatonnesoi*). In 1821 it was burned to the ground during a fight between the Turks and the Greeks, and a large number of its Greek population killed or enslaved. It is now one of the most thriving towns in the Levant, with a purely Greek population distinguished for its commercial, industrial, and maritime enterprise. The exports are olive oil, soap, and raki; and a fleet of fishing-boats supplies Constantinople and Smyrna with fish; the exports in 1899 were valued at £944,743, and the imports at £286,425. It is the seat of a British vice-consulate. Population, 36,000.

Aix-la-Chapelle, German *Aachen*, a town and watering-place of Prussia, in the Rhine prov., between the Meuse and the Rhine, 44 miles W.S.W. from Cologne by the railway to Liège. It possesses more than thirty churches, besides the cathedral. A handsome building was put up in 1886-89, behind the façade (1267) of the old town hall, to accommodate the archives. The Suermondt museum contains collections of antiquities, pictures, arms, and industrial art objects. There are two or three technical schools, a commercial college, a commercial high school (opened in 1898), a deaf and dumb asylum, lunatic asylums, a teachers' seminary, a polytechnic, a technical high school, and a newspaper museum. In the vicinity are coal-mines employing about 9000 men. This city is the seat of a very active commerce in cereals, timber, leather, coal, metals, wool, wine, &c. In 1897 the town of BURTSCHEID was incorporated with Aix-la-Chapelle. Burtscheid also has thermal baths (140° to 160° Fahr.), and carries on the same industries as Aix-la-Chapelle. Population (1885), 95,725; (1895), 110,551; (1901), 135,235.

Ajaccio, the chief town of the island of Corsica, a department of France, stands on the west side of the island. It lies 676 miles S.E. of Paris, and is the terminal station of railways from Bastia and Calvi. The library (35,000 volumes), a fine collection of pictures, and a communal college, all now in the Palais Fesch, were founded by the cardinal of that name, half-brother of Napoleon's mother. The culture of the citron has greatly extended in recent years, and gallic acid is now an important export. The Citadelle harbour affords good anchorage, but the port accommodation is indifferent. The total length of quays is 2000 feet, with a depth alongside of from 9 to 22 feet. In 1899, 640 vessels of 213,370 tons entered, and 650 of 214,107 tons cleared. Population (1881), 15,351; (1891), 17,248; (1896), 17,398, (comm.) 18,553; (1901), 21,779.

Ajaigarh, a native state of India, in Bundelkhand, under the Central India agency; lying between 24° 45′ and 24° 58′ N. lat., and between 80° 4′ and 80° 22′ E. long. It has an area of 802 square miles; and a population of 93,048, being 116 persons per square mile. The chief, who is a Bundela Rajput, bears the title of Sawai Maharaja. He has an estimated revenue of about Rs.2,25,000, and pays a tribute of Rs.7010. He resides at the town of Naushahr, at the foot of the hill-fortress of Ajaigarh, from which the state takes its name. The state suffered severely from famine in 1868-69, and again in 1896-97.

Ajmer, a city of British India, in Rajputana, which gives its name to a district and also to a petty province called Ajmer-Merwara; situated in 26° 27′ N. lat. and 74·44° E. long., on the lower slopes of Taragarh Hill, in the Aravalli Mountains. It is an important station on the Rajputana railway, 615 miles from Bombay and 275 miles from Delhi, with a branch running due south to the Great Indian Peninsula main line. The city is well laid out, with wide streets and handsome houses. It is still surrounded by a stone wall. The educational institutions include a college, with 212 students in 1897-98, and the Mayo Rajkumar College, opened in 1875, for training the sons of the nobles of Rajputana on the lines of an English public school, with 63 pupils in 1897-98, maintained at a total cost of Rs.47,479. Population (1867), 34,763; (1881), 48,735; (1891), 68,843; (1901), 75,759, showing an increase of 10 per cent. The district of AJMER, which forms the larger part of the province of Ajmer-Merwara, has an area of 2070 square miles. Population (1891), 422,359, being 204 persons per square mile; (1901), 366,800, showing a decrease of 13 per cent. Besides the city of Ajmer, it contains the military station of Nasirabad; population, 21,710.

Ajmer-Merwara, a division or petty province of British India, in Rajputana, consisting of the two districts of Ajmer and Merwara, separated from each other and isolated amid native states. The administration is in the hands of a commissioner, subordinate to the governor-general's agent for Rajputana. The capital is Ajmer city. The area is 2711 square miles. The population in 1891 was 542,358, being 200 persons per square mile, the classification according to religion being: Hindus, 437,988, or 81 per cent.; Mahommedans, 74,265, or 13 per cent.; Jains, 26,939, or 5 per cent.; Christians, 2683; and "others," 483; in 1901 the population was 476,330, showing a decrease of 12 per cent., due to the results of famine. Among Hindus, the Rajputs are landholders, and the Jats and Gujars are cultivators. The Jains are traders and money-lenders. The aboriginal tribe of Mers are divided between Hindus and Mahommedans. In 1897-98 the total cultivated area was returned at 404,413 acres, of which 62,305 acres were twice cropped. The chief crops are millet, wheat, cotton, and oil-seeds. The irrigated area was 142,287 acres, of which 107,677 were irrigated from wells, and 33,955 from tanks. The land revenue was Rs.4,42,526, being at the rate of R.1:3:11 per cultivated acre, and 14 annas per head of population. The total number of schools was 192, with 10,771 pupils; and the total expenditure on education was Rs.92,463. There are 12 factories for ginning and pressing cotton, the chief trading centres being Beawar and Kekri. Together with the surrounding country, Ajmer-Merwara suffered very severely from the famine of 1899-1900. In June 1900 the number of persons in receipt of relief was 143,000, being more than one-fourth of the total population.

'Akabah, Gulf of, the classical *Ælaniticus Sinus*, from the town of Ælana at its head; a continuation southward of the Jordan-'Araba depression. Raised beaches on the coast show that there has been an elevation of the sea-bed of 200 feet. Near the head of the gulf is Jezíret Faraún, mediæval *Graye*, a rocky islet with the ruins of a castle built by Baldwin I. (*circ.* 1115). The village of 'AKABAH was transferred from Egypt to Turkey in 1892, and has a small import trade. Near it was *Elath*, the port from which Solomon's fleet sailed to Ophir, which as *Ælana* was the station of the tenth Roman legion, and a place of commercial importance. As *Haila* or *Ailat*, under the Arabs, it was in the 10th century the great port of Palestine and the emporium of the Hejáz.

Akalkot, a native state of India, in the Deccan division of Bombay, ranking as one of the Satara Jagirs, situated between the British district of Sholapur and the Nizam's dominions. Area, 498 square miles; population

(1891), 75,744; (1901), 82,052, showing an increase of 8 per cent. In 1897-98 the gross revenue was Rs.3,52,867, of which Rs.39,102 was expended on public works; he tribute is Rs.14,592; the number of police was 59; there were 38 schools, with 1897 pupils. The chief, who is a Mahratta of the Bhonsle family, resides at Poona on a pension, while the state is under British management. The town of Akalkot is situated in 17° 31′ N. lat. and 76° 15′ E. long., near the Great Indian Peninsula railway, which traverses the state. Population, 6551.

Akanyam, R. See Nile.

Akassa. See Nigeria.

Akhal-teke. See Transcaspian Territory.

Akhaltsykh (Georgian *Ahaltsikhe*, "new fortress"), a fortified district town of Russia, Transcaucasia, government of Tiflis, 67 miles east of Batum, situated on a tributary of the Kura, at an altitude of 3370 feet. It enjoys an excellent climate and its houses are scattered amidst gardens. The new town is on the right bank of the river, while the old town and the fortress are on the opposite bank. It has a considerable inland trade, and brown coal is found in the neighbourhood. In 1897 the population, of whom many were Armenians, was 15,387.

Ak-hissar, the classical *Thyateira*, the "town of Thya," situated in a fertile plain, on the Geurduk Chai (*Lycus*), in the Smyrna vilâyet. Thyateira was an important station on the Roman road from Pergamos to Laodicea, and one of the "seven churches" of Asia (Rev. ii. 18). The town is connected with Smyrna by railway and exports cotton, wool, opium, cocoons, and cereals. Population, 13,000 (Moslems, 8200; Christians, 4800).

Akhtyrka, a district town of Russia, government of Kharkoff, near to the Vorskla river, connected by a branch (11 m.) with the railway from Vilno to Nikolaevsk. It is surrounded by moving sands, and often inundated. It has a beautiful cathedral, built upon a plan by Rastrelli in 1753, to which numerous pilgrims come every year to venerate the ikon of the Virgin of Akhtyrsk. There is an active trade in corn, cattle, and the produce of domestic industries. Population (1897), 23,390.

Akim. See Gold Coast.

Akkerman (Turkish *Ak-kerman*, "white town"), a district town, formerly a fortress, of South-West Russia, government of Bessarabia, situated on the right bank of the estuary of the Dnieper, 12 miles from the Black Sea. It was taken by the Russians in 1770 and 1774 and returned to the Turks, but was definitely annexed to Russia in 1881. Its proximity to Odessa gives it an advantageous position for trade, and it does a thriving business in wine, salt, fish, wool, tallow, &c. The town, with its three suburbs, contains beautiful gardens and vineyards. In 1897 the population was 28,303, or 40,000 including the suburbs.

Akmolinsk, in Asiatic Russia, the north-eastern of the three provinces belonging to the general governorship of the Steppes, formerly known as the Kirghiz Steppe; bounded by Turgai on the W., Tobolsk on the N., Tomsk on the E., and Russian Turkestan on the S. Area, 211,566 square miles, of which 4535 are lakes. It is low and dotted with salt lakes in its northern portion, and sandy on the banks of the Irtysh. An undulating plateau stretches in the middle, and is watered by the Ishim, the plains gradually rising southwards, where a wide spur of the Tarbagatai Mountains runs north-westwards, containing gold, copper, and coal. Many lakes, of which the largest is Denghiz, are scattered along the northern slope of these hills. To the south of these hills, towards Lake Balkhash, situated on its south-eastern frontier, and to the north-west of this lake, spreads a wide waterless desert, Bek-pak-dala, or Famine Steppe (Golodnaya). The province is watered by the Ishim, tributary of the Irtysh (which flows near to the eastern frontier) and the Nura. The climate is very continental and dry, the average temperatures at Akmolly being: year 35°, January 1·5°, July 70°; yearly rainfall, only 9 inches. The population, which was 678,957 in 1897 (324,587 women) consists chiefly of Russians in the northern and middle portions, and Kirghiz (about 350,000), who breed large quantities of cattle, horses, and sheep. The urban population was only 74,069. Agriculture is successfully carried on in the north, where the Siberian railway runs from Zlatoust to Omsk through a very fertile, well-populated region. Steamers ply on the Irtysh. The province is divided into five districts, the chief towns of which are: Omsk, formerly capital of West Siberia (37,470 inhabitants); Akmolinsk, or Akmolly, chief town of the province (9560), situated on the Ishim, 285 miles south-west of Omsk, and chief centre for the caravans coming from Tashkent and Bukhara; Atbasar, 3030; Kokchetav, 5000; and Petropavlovsk, 20,014.

Akola, a town and district of India, in Berar or the Haidarabad Assigned Districts, under British administration. The town is on the Morna river, 930 feet above the sea; railway station, 363 miles from Bombay. Population (1881), 16,608; (1891), 21,470; municipal income (1897-98), Rs.45,057. It is a centre of trade in raw cotton. There are 13 factories for ginning and pressing cotton, with an outturn of 80,000 bales. It has a high school, with 202 pupils in 1896-97; a training college, with 69 students; an industrial school, supported by a Christian mission; an engineering class; two printing presses, each issuing a vernacular newspaper.

The district of Akola has an area of 2660 square miles; population (1881), 592,792; (1891), 574,782, showing a decrease of 3 per cent; average density, 216 persons per square mile; (1901) 582,763, showing an increase of 1 per cent. Land revenue and rates in 1897-98 amounted to Rs.22,34,308, the incidence of assessment being R.1:7:2 per acre; the cultivated area was 1,303,757 acres, of which 9344 are irrigated from wells; number of police, 601 men; the number of boys at school in 1896-97 was 12,412, being 27·8 per cent of the male population of school-going age; the registered death-rate in 1897 was 54·9 per thousand. The principal crops are millet and cotton.

Akron, a city of Ohio, U.S.A., the capital of Summit county, situated in 41° 05′ N. lat. and 81° 32′ W. long. in the north-eastern part of the state, at an altitude of 1000 feet, being on the divide between Lake Erie and Ohio river. The water supply is derived from wells. The plan of the streets is quite irregular; there are six wards, and the city is entered by no fewer than six railways, giving it excellent connexions in all directions. Its industries are chiefly manufacturing, and its products consist largely of agricultural implements, cement, brick, and tiles. Buchtel College, one of the smaller institutions of learning, is situated here. The population in 1880 was 16,512, in 1890 it was 27,601, and in 1900 it was 42,728.

Ak-Shehr, the classical *Philomelion*, a town in Asia Minor, in the Konia vilâyet, situated at the edge of a fertile plain, on the north side of the Sultan Dagh. Philomelion was on the great Greco-Roman highway from Ephesus to the east, and to its townsmen the Smyrniotes wrote the letter that describes the martyrdom of Polycarp. The town is connected by railway with Konia, Smyrna, and Constantinople. Population, 15,000 (Moslems).

Aksu (*White Water*), a town of the Chinese empire, Eastern Turkestan, in 41° 7′ N. and 79° 7′ E., 70 miles E. of Uch-Turfan and 270 miles N.E. of Yarkand, near to the left bank of the Aksu river, which takes its origin in the Tian-shan Mountains and joins the Tarim. It belongs to the series of oases (Uch-Turfan, Bai, Koucha, &c.) situated at the southern foot of the eastern Tian-shan Mountains. The town, which is supposed to have about 6000 houses, is enclosed by a wall. It is an important centre for caravan routes, and has a considerable trade. Extensive cattle breeding is carried on by the inhabitants.

Aktyubinsk (Ak-tube), a district town and fort of Russian Central Asia, province Turgai, situated on the Ilek river, 135 miles S.E. of Orenburg. It is the centre for the administration of the Kirghiz, with whom a lively trade is carried on. In 1897 the population was 2840.

Akyab, a district and city in the Arakan division of Burma, lies along the north-eastern shores of the Bay of Bengal. The district area is 5136 square miles. Population (1891), 415,305; (1901), 482,374. There were 2040 villages paying a revenue of Rs.16,91,191 in 1898-99. Buddhists and Jains numbered 258,259, Mahommedans 119,157, Hindus 9762, aborigines 28,234, and Christians (European and native) 893. Of the total area of 3,287,040 acres, the area under cultivation was 590,991, there were 64,950 acres lying fallow, the cultivable waste amounted to 1,669,478 acres, and 961,621 acres were not capable of cultivation. The rainfall in 1898-99 was 193·49 inches. Akyab, the chief town, had in 1891 a population of 37,938; in 1871-72 the total was 15,281. It has a municipality with a committee of 16 members, 10 of whom are elected. There is a second-class district jail. The export of rice from Akyab has increased greatly of late years. There are two oil-wells in the district, both on Boronga island, worked under the Canadian oil-boring system. During the year 1898-99, 290 vessels with a tonnage of 167,158 entered the port, and 282 of a burden of 166,752 cleared.

Ala, a town in South Tyrol, Austria, in the government district of Rovereto, on the Adige river, at the entrance of the Ronchi valley. It is the last station on the Brenner railway, and has an Austrian and an Italian custom-house. Silk and velvet manufactures. Population in 1890, 4646; in 1900, 4933, chiefly Italian.

Alabama, one of the Southern States of the American Union, situated between 35° and 30° 13′ N. lat., and 84° 53′ and 88° 35′ W. long., and bounded on the N. by Tennessee, on the E. by Georgia, on the S. by Florida and the Gulf of Mexico, and on the W. by Mississippi. In the last quarter of the 19th century Alabama experienced a new era of prosperity. During the decade of the Civil war the cotton product had fallen off from 989,955 bales in 1860 to 429,482 bales in 1870, and the corn product from 33,226,282 bushels to 16,977,948 bushels, these being the leading products of the State, which was almost entirely agricultural. Politically and economically the result of the war was even more marked. The emancipation and enfranchisement of the negroes, who constituted almost half of the population (475,510 coloured in a total of 996,992), threw the Government into the hands of strangers, "carpet-baggers," who were attracted mainly from the north by the prospect of political power. When these went into office under the constitution born of the bayonet, their auditor said in his first report: "Alabama stands in a proud position in the financial world. . . . Nothing but gross mismanagement of her finances will cause her credit to decline."

The State's bonded debt was . . .	$5,270,000.00
Educational fund and miscellaneous .	$3,085,683.51
Total	$8,355,683.51

Under the new régime the State's endorsement was granted to railways to the extent of $16,000 a mile; and many roads were begun, partially completed, and then abandoned. So gross was the mismanagement in general that, before the close of 1873, the governor was compelled to report to the legislature his inability "to sell for money any of the State bonds," a condition of things which, according to an official report (30th September 1874), had resulted from the fact that the debt had grown to the sum of $25,503,593, including both direct and endorsed railway securities. At this crisis the white people, worn out by misgovernment at the hands of irresponsible rulers, resolved to re-establish the public affairs of the commonwealth upon a normal basis. Under the lead of George S. Houston, the bulk of the white voters united in the democratic and conservative party triumphed in the memorable contest of 1874, electing not only the governor, but large majorities in both branches of the legislature. The affairs of the State were again in the hands of the taxpayers. That event made possible the political, economic, and industrial reorganization which has since lifted the State to its present condition of prosperity, not only as an agricultural community, but as one of the great coal and iron-producing States of the Union.

Under the constitution of 1875, which superseded that of 1868, and which is still in force, official salaries and the power of the legislature to indulge in financial extravagance were severely restricted. The debt, then beyond the ability of the State to bear, was readjusted, and was so reduced by amicable settlements that, on 30th September 1888, it had shrunk from $25,000,000 to $12,085,220. Owing to subsequent payments, the total bonded debt amounted on 1st March 1898 to only $9,357,600.

The total population, which had increased in 1890 to 1,513,017 (833,718 whites and 679,299 negroes), was 1,828,697 in 1900, showing an increase for the decade of 20·8 per cent. The total land surface of Alabama is, approximately, 51,540 square miles, and the density of population was therefore 35·4 per square mile in 1900, as compared with 29·3 ten years earlier. There were, in 1900, 201 incorporated cities, towns, and villages, and of these 9 had a population in excess of 5000, and 3 in excess of 25,000. These three were Mobile, with 38,469 inhabitants, Birmingham, with 38,415, and Montgomery, with 30,346. The proportion of rural to urban population is increasing. The total taxable values, which in 1876 were $135,535,790, were in 1898 $256,256,295, the total state tax being 5½ mills on the total values. The total cotton product, which in 1870 was 429,482 bales, was in 1899, 1,130,000 bales.

The main feature in the modern transformation is the vast development of the mineral region, which occupies the north-eastern two-fifths of the State. The south-eastern fourth of this area, the Gold Belt, produces gold, copper, pyrites, and mica. In the north-western three-fourths are the three coal-fields—Warrior, Cahaba, and Coosa—aggregating 8000 square miles (about 2000 productive), separated by narrow north-east and south-east valleys, in which are bauxite, barytes, iron ores, and limestones. Thus all the raw materials for the production of iron occur in close proximity, with no natural barriers between. The total annual coal production, which in 1870 amounted only to 13,200 tons, had risen in 1875 to 67,200; in 1880 to 380,000; in 1885 to 2,492,000; in

1890 to 4,090,409; in 1895 to 5,693,775; and in 1899 to 7,500,000 estimated. Prof. M'Calley has reached the conclusion that the three coal-fields (Warrior, Cahaba, and Coosa), combined, probably contain an aggregate of at least 42,100,000,000 tons. Tests made by the United States navy have established the superior quality of certain seams of this coal for steam purposes, while the coke tonnage of the Pratt and Blue Creek seams of the Warrior field (1,609,839 tons in 1898) is second only to the famous Connellsville district of Pennsylvania. The pig-iron production, which during the year 1870 amounted only to 7060 tons, had risen in 1875 to 22,418; in 1880 to 68,925; in 1885 to 203,069; in 1890 to 816,911; in 1895 to 854,667; and in 1899 to 1,083,905. The supply of iron ore (red and brown) is practicably inexhaustible. That used in the Birmingham district is principally of the red fossiliferous kind derived from Red Mountain, the vein running about 20 feet thick at the outcrop, and extending under cover at an angle of from 15 to 20 degrees from the horizontal to an unknown depth. Birmingham, Ala., is now the third largest point of export of pig-iron in the world,—Middlesbrough in England being the first, and Glasgow in Scotland the second. Within the eighteen months ending 1st January 1898 there were exported from Birmingham 297,000 tons of pig-iron to all parts of the world. During the year 1899 the production of steel began in the Birmingham district, one plant producing 9670 tons and another 2363.

To render the waterways available for commerce, the Federal Government has spent millions of dollars. The Mobile river, with its branches, resembles a gigantic tree rising from tidal limits in one of the best harbours on the Gulf of Mexico, and spreading northward, eastward, and westward into Tennessee, Mississippi, and Georgia. The total of mileage of rivers in use to-day, either for commercial purposes or in the process of improvement by the Federal Government, is 2214 miles. On either side the mineral region is pierced by the Warrior and Coosa rivers, destined soon to be the great highways through which the coal and iron products are to be brought in barges to tidal limits for shipment through the port of Mobile. The deepening of Mobile harbour in the south, the construction of the Muscle Shoals Canal on the Tennessee river in the north, and the improvement of the interior rivers have involved an expenditure upon the part of the Federal Government of about twelve millions of dollars, nearly all of which has been appropriated since 1870. The most important part of the work now in progress is the improvement of the Warrior river, the early completion of which has been assured by the action of Congress placing it under the contract system directed by the secretary of war. In order, however, to give an outlet for coal and iron by water from the heart of the best mineral region, it is necessary to cut a canal about 64 miles long from Birmingham to the Warrior, *viâ* Bessemer. After a careful survey Major Rossell, the Government engineer-in-charge, declared that "the project is both feasible and advisable." A waterway will thus be opened through which coal and iron, mined within 300 miles of tidal limits, can be floated to the sea. Experts estimate that a ton of pig-iron can be loaded at Birmingham and landed at Mobile at 49 cents, a rate 55 cents lower than any yet in existence. The cost of steam coal at Mobile is now about \$2.80 a long ton, the cost of railway transportation being about \$1.25. After the canal and Warrior route has been made available, a scrupulous estimate places the cost of such coal at Mobile at \$1.50. The railway system of the State has also been steadily developing. The 1602 miles of railway in operation in 1871 had increased to 3560 miles at the close of 1898.

Mobile is the only seaport of the State. The bay is about 32 miles long, with an average width of 16 miles. The United States Government has dredged a channel, now 23 feet deep, from the docks to deep water. At the mouth of the bay there is a deep water cup, with a depth of from 30 to 60 feet, and an area of 5 or 6 square miles. The bar separating this deep water from the water of the gulf has a depth of 23-1/2 feet, which has been increasing by natural processes since the earliest Government records. Estimates by Government engineers have settled the fact that a channel across this bar can be cut to a depth of 30 feet, with a width of 300 feet, by the excavation of 220,000 cubic yards of material at a cost insignificant when compared with the value of the improvement. If that work is completed, Mobile Bay may be entered at any time by vessels drawing 28 feet—something that can be said of few land-locked harbours.

During the year ending 30th June 1870, 105 vessels of 70,249 tons entered, and 129 vessels of 81,276 tons cleared, in the foreign trade. During the year ending 30th June 1900, 755 vessels of 549,198 tons entered, and 717 vessels of 505,273 tons cleared. For the year ending 30th June 1901 the total imports were \$3,008,449, and the total exports, \$11,837,105. The thirteen mills manufacturing cotton goods in 1870 have been increased to fifty-two, with 813,939 spindles and 18,590 looms, the total capital invested amounting to \$16,278,780. The annual output of the cotton oil mills of the State is 139,500 tons, valued at \$2,929,500. The lumber and shingle mills, numbering about 1000, represent an invested capital of \$18,700,000, the average output per day for each mill being 15,000 feet. The annual product of rosin and naval stores is valued at \$1,150,000.

The number of national banks in operation, 31st October 1900, was 30, with paid-up capital of \$3,555,000, and outstanding circulation of \$1,968,665. The state banks numbered in the same year 62, with a capital and surplus of \$3,292,874; the private banks 26, with a capital and surplus of \$1,021,078; and the loan and trust companies 9, with capital and surplus of \$869,723.

In 1890 Alabama had 6013 church edifices, and church property valued at \$6,768,477. There were 559,171 communicants or members, of whom 258,405 were Baptists, 242,624 Methodists, 21,502 Presbyterian, and 13,230 Roman Catholics.

The law establishing a public school system was enacted in 1854, but it was twenty years after that date before the period of substantial, permanent growth began. The school term ranges from four to nine months, and tuition is free. Separate schools are provided for children of African descent. The funds for maintaining the public schools are derived from a direct appropriation from the state treasury, a special state school tax, a poll tax, interest on the sixteenth section fund, and municipal appropriations. In 1855 they amounted to \$237,515.39. In 1900 the appropriations for common school education amounted to \$1,100,000.00. The school age is from seven to twenty-one years. In 1855 the enumeration showed a white school population of 145,588. In 1899 the number was 633,546—white, 350,667; coloured 282,879. The State is thoroughly committed to the policy of universal education at governmental expense, and is making rapid progress in that direction. Besides the public schools, Alabama has a number of private and denominational institutions of learning of high grade. All the leading denominations are well represented in this number. The amount expended on private and denominational education annually approximates \$300,000.

The special question with which Alabama, in common with her sister Southern States, is confronted, is the race problem. The constitution of 1875, under which the political supremacy of the white race was re-established, provides (Art. XIII. sec. 1) that a system of public schools shall be maintained throughout the State "for the equal benefit of the children thereof . . . but separate schools shall be provided for the children of citizens of African descent." From that time negro children have been enjoying in their separate schools the equal benefits of an educational fund of approximately one million dollars a year, the bulk of which is produced by taxes contributed by the whites. In spite of this, however, the great mass of negroes, in whose hands rests so large a proportion of the political power, have little or no training in the duties of citizenship. In the hope of solving the race problem upon a broad and humane basis a South Conference was formed in Alabama, the first meeting of which was held under brilliant auspices. The chief difficulty is, of course, that of franchise. If it is to be limited by educational or property qualifications, whatever disabilities may be imposed must rest upon both races alike. If the negro shall be disfranchised by his illiteracy, he can remove the disability in the schools which the white people of the State maintain for his equal benefit. Such a plan, if adopted as in other Southern States, will result in a gradual and conservative political emancipation. (H. T.*)

Alabama Arbitration. See ARBITRATION, INTERNATIONAL.

Alagoas, an Atlantic state of Brazil. Its area covers 22,580 square miles. The population in 1872 was 348,009, and in 1890, 511,440. The capital is Alagôas Maçeió, and amongst other towns are Camaragibe, Penedo, S. Miguel dos Campos, Pilar, and Porto Calvo. The state has railways from Maçeió to Muricy and Viçosa, and from Piranhas to the Rio Moxotó. ALAGÔAS MAÇEIÓ, with a population of 30,000, is an important shipping port, visited by Transatlantic steamers, and the terminus of the Alagoas railway (55 miles)

Alais, chief town of arrondissement, department of Gard, France, 27 miles N.W. by N. of Nimes, on railway from Paris to Nimes, *viâ* the Cevennes. Amongst the public institutions are the municipal chemical laboratory and two hospitals. Sericulture is extensively engaged in, and silk, both raw and manufactured, furnishes a large part of the town's widespread trade. Pasteur here prosecuted his early investigations. A statue has been erected to his memory. The chemist Dumas was a native of Alais. Population (1881), 16,945; (1891), 18,333; (1896), 18,249.

Alajuela, a province of Costa Rica, Central America. Its area is 4250 square miles, and the population in 1897 numbered 60,000. The capital is Alajuela, and amongst other considerable towns are San Ramón, Grecia, Atenas, and Naranjo. The province is divided into seven cantons.

Alajuela, capital of the above province, situated at the terminus of the railway line from Limon, 12 miles W. of San José, and 23 miles W.N.W. of Cartago. It has some trade with Punta Arenas, 23 miles distant by mule road, and on the formation of the new port on the Pacific at the head of the Gulf of Nicoya will increase in importance. Population, 7000.

Alameda, a residential city of Alameda county, California, U.S.A., is situated in 37° 46′ N. lat. and 122° 16′ W. long., on the east side of San Francisco Bay, directly south of Oakland, and separated from it by San Antonio creek. Its site is low and level and its plan fairly regular. It is entered by the Southern Pacific railway. The population in 1880 was 5708, in 1890 it was 11,165, and in 1900 it was 16,464.

Alantika, Mount. See CAMEROON.

Alarcon, Pedro Antonio de (1833-1891), Spanish writer, was born on 10th March 1833 at Guadix. He graduated at the university of Granada, studied law and theology privately, and made his first appearance as a dramatist before he was of age. Deciding to follow literature as a profession, he joined with Torcuato Tarrago y Mateos in editing a Cadiz newspaper entitled *El Eco de Occidente.* In 1853 he travelled to Madrid in the hope of finding a publisher for his long continuation of Espronceda's celebrated poem, *El Diablo Mundo.* Disappointed in his object, and finding no opening at the capital, he settled at Granada, became a Radical journalist in that city, and showed so much ability that, in 1854, he was appointed editor of a very advanced journal, *El Látigo*, published at Madrid. The extreme violence of his polemic writings led to a duel between him and the Byronic poet, José Heriberto Garcia Quevedo. The earliest of his novels, *El Final de Norma*, was published in 1855, and though its construction is feeble, it brought the writer into notice as a master of elegant prose. A small anthology, called *Mañanas de Abril y Mayo* (1856), proves that Alarcón was recognized as a leader by young men of promise, for among the contributors were Castelar, Manuel del Palacio, and López de Ayala. A dramatic piece, *El Hijo pródigo*, was hissed off the stage in 1857, and the failure so stung Alarcón that he enlisted under O'Donnell's command as a volunteer for the war in Morocco. His *Diario de un testigo de la guerra de Africa* (1859) is a brilliant account of the events of the expedition. The first edition, amounting to fifty thousand copies, was sold within a fortnight, and Alarcón's name became famous throughout the Peninsula. The book is not in any sense a formal history; it is precisely what its title implies, a series of picturesque impressions told with remarkable force. On his return from Africa Alarcón did the Liberal party much good service as editor of *La Política*, but his marriage to a devout lady, Paulina Contrera y Reyes, in 1866, led him to modify his political views considerably. On the overthrow of the monarchy in 1868, Alarcón advocated the claims of the Duc de Montpensier, was extremely neutral during the period of the Republic, and declared himself a Conservative upon the restoration of the dynasty in December 1874. These political variations alienated Alarcón's old allies and failed to conciliate the royalists. But though his political influence was ruined, his success as a writer was greater than ever. The publication in the *Revista Europea* (1874) of a short story, "El Sombrero de tres picos," a most ingenious resetting of an old popular tale, made him almost as well known out of Spain as in it. This remarkable triumph in the picaresque vein encouraged him to produce other works of the same kind; yet, though his *Cuentos amatorios* (1881), his *Historietas nacionales* (1881), and his *Narraciones inverosimiles* (1882) are pleasing, they have not the delightful gaiety and charm of their predecessor. In a longer novel, *El Escándalo* (1875), Alarcón had appeared as a partisan of the neo-Catholic reaction, and this change of opinion brought upon him many attacks, mostly unjust. His usual bad fortune followed him, for while the Radicals denounced him as an apostate, the neo-Catholics professed that *El Escándalo* was tainted with Jansenism. Of his later volumes, written in failing health and spirits, it is only necessary to mention the *Capitán Veneno* and the *Historia de mis libros*, both issued in 1881. Alarcón was elected a member of the Spanish Academy in 1875. He died at Madrid, after a long and painful illness, on the 20th of July 1891. The impression which he makes upon the reader is brilliant, but unenduring. His later novels and tales are disfigured by their didactic tendency, their feeble drawing of character, and even by certain Gallicisms of style. But, at his best, Alarcón may be read with great pleasure. The *Diario de un testigo* is still unsurpassed as a picture of campaigning life, while "El Sombrero de tres picos" is a very perfect example of malicious wit and minute observation.

(J. F. K.)

Alard, Jean Delphin (1815-1888), a distinguished French violinist and teacher, was born at Bayonne, 8th May 1815, and died at Paris, 22nd February 1888. He was a pupil of the Paris Conservatoire, under Habeneck, from 1827; he succeeded Baillot as professor there in 1843, and retained the post till 1875. His playing was full of fire and point, and his compositions, consisting mainly of fantasias and such things, had a great success in France, while his *Violin School* had a wider vogue and considerably greater value.

Ala-shehr, the classical *Philadelphia*, a town of Asia Minor, in the Smyrna vilâyet, situated in the valley of the Kuzu Chai (*Cogamus*), at the foot of Boz Dagh (*M. Tmolus*). Philadelphia was a Pergamene foundation, was one of the "seven churches" of Asia, and was called "Little Athens" on account of its festivals and temples. It was an independent, neutral city when taken in 1390 by Sultan Bayazid I., and an auxiliary Christian force under the Emperor Manuel II. The town is connected by railway with Konia and Smyrna. There are small industries and a fair trade. From one of the mineral springs comes a water known in commerce as "Eau de Vals." Population, 22,000 (Moslems, 17,000; Christians, 5000).

Alaska.—Alaska, formerly Russian America, is a territorial district of the United States, occupying the north-western extreme of North America and adjacent islands. The inhabitants of the Aleutian islands called the continental land eastward from them Alayeksha, which was corrupted by early Russian explorers to Aliashka. The name was subsequently restricted to the peninsula, and, in the simplified form now adopted, was proposed as a name for the new territory by Charles Sumner in a speech before the U.S. Senate advocating its purchase. The territory of Alaska comprises, first, all that part of continental North America west of the 141st meridian from Greenwich; secondly, the eastern Diomede Island in Bering Strait and the islands of Bering Sea, and the Aleutian chain east of a line drawn from the Diomedes in a south-westerly direction so as to pass midway between Attu Island of the Aleutian, and Copper Island of the Commander group; lastly, of a narrow strip of coast with its adjacent islands, north of lat. 54° 40′ N., west of Portland Channel, and thence, as designated in the treaty of cession, bounded to the east and north by a line, following "the summit of the mountains situated parallel to the coast" "to the point of intersection with the 141st meridian," provided that when this line "shall prove to be at a distance of more than ten marine leagues from the ocean the limit" "shall be formed by a line parallel to the windings of the coast and which shall never exceed the distance of ten marine leagues therefrom." The islands comprise several main groups: the Alexander Archipelago, extending from the southern boundary north-westward to Cape Spencer; the Kadiak group, south-east of the peninsula of Alaska; the Catherina Archipelago, westward from the end of the peninsula to Attu, and is further subdivided into four minor groups—the Fox, Andreanoff, Rat, and Nearer Islands, often collectively designated the Aleutian Islands. Northward from the Aleutian group, in Bering Sea, are the Pribiloff or Fur Seal Islands, St Matthew, and St Lawrence, at subequal distances, and the large island of Nunivak eastward near the coast. The estimated area of the Alexander Archipelago is 31,205 square miles, and of the Aleutians 6391 square miles. The total area of the territory is approximately 580,107 square miles. From north to south it extends about 1200 miles, and from east to west nearly 2400 miles.

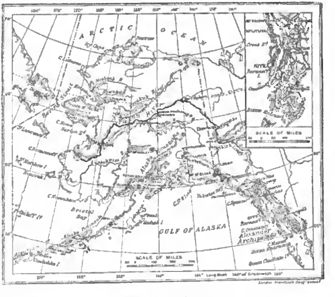
Sketch Map of the Aleutian Islands.

The coast-line, omitting minor sinuosities but including the islands, exceeds 16,000 miles. Beginning at the south and proceeding northward and westward the most conspicuous capes are Muzon, Ommaney, Spencer, St Elias, Newenham, Vancouver, Romanzoff, Prince of Wales (the westernmost point of the continent), Lisburne, Icy Cape, and Point Barrow, the last being the most northern point of the territory and situated in lat. 71° 20′ N. and long. 156° 15′ W. Three great peninsulas project from the shores: Kenai, to the east of Cook's Inlet, the peninsula of Alaska, and the Kaviak peninsula between Kotzebue and Norton Sounds. The great embayment north of a line drawn from Queen Charlotte Islands to Kadiak has been named the Gulf of Alaska. Omitting the interstices of the archipelago, Yakutat Bay, Prince William Sound, Cook's Inlet, are the principal arms of the gulf. The eastern shores of Bering Sea are indented by Bristol Bay, north of the Alaska peninsula, and Norton Sound, south of the Kaviak peninsula; north of the latter Kotzebue Sound is the only inlet of importance.

The entire north-west coast of America is folded by mountain-building forces in general harmony with the trend of the coast. The state of Washington, British Columbia, and South-eastern Alaska have had their strata violently and sharply crumpled, the lines of elevation and depression being roughly N.N.W. and S.S.E., with occasional transverse depressions. These have been the site of a vast system of glacial action which has deepened and modelled the valleys, though its processes were never carried far enough to cut down and remove the intervening ridges. The result is what has been aptly termed a "sea of mountains," in which the existing glaciers, stupendous as many of them are, are mere tatters of the ice that preceded them. Consequently this coast, unlike that of Norway, which in outline is not dissimilar, is bold, steep, and craggy, with few beaches and hardly level shore enough anywhere to build a cabin on or cultivate a garden patch. Nevertheless the mountain sides are densely wooded with evergreens, the snow-line being at an approximate elevation of 3000 to 5000 feet, according to location. The passages of the archipelago are merely submerged portions of this broken area, and would be reduplicated to the eastward were the level of the land to be still further depressed. The summits are of unusually even elevation, and, near the sea, present no peaks of remarkable height. North-westward from Cape Spencer the mountain-building forces seem to have been more intense and the ranges of the Fairweather and St Elias Alps rise to great heights at a short distance from the sea. Mt. Fairweather (15,300 feet), Lituya (12,000), Laperouse (10,750), Cook, Vancouver, St Elias (18,100), and, further inland, Logan (19,500), are the most noteworthy summits of this region. The Muir glacier, the Malaspina, and the Bering glacier flank portions of these mountains and rank next to those of Greenland. These mountains continue westward parallel with the coast and terminate as the backbone of the Kenai peninsula. Parallel uplifts further inland near the meridian of 145° W. rise to great heights. Mt. Tillman has been assigned a height of 16,600 and Mt. Wrangell of 17,500; the latter, on somewhat insufficient evidence, has been ranked as a volcano. Still further north and west a range which corresponds in general with the line of the range of the Alaska peninsula further south and west, and which has been named the Alaskan mountains, culminates in lat. 64° N. in the peak of Mt. M'Kinley, rising over 20,000 feet. Beyond the Alaskan range and its foothills lie broad river valleys, north-westward from which are ranges of comparatively low hills, none of which have been recorded as exceeding 3500 feet, and beyond which again stretches the Arctic tundra.

Much of the rock of North-Western Alaska is volcanic. Along the great line of orographic folding indicated by the Alaskan range and the Aleutian chain numerous remarkable volcanic peaks exist, varying in height up to 12,000 feet. Enumerating them from Cook's Inlet westward, and omitting all cases of doubtful vulcanicity, the most notable are Redoubt Volcano, Iliamna, Augustin, Olai, Chiginagak, Pavloff, Isanotski (extinct), Shishaldin, Akutan, Makushin, Vsevidoff, Atka, Gareloi, and Semisopochnoi, all of which, with the exception noted, emit steam or smoke, or show other evidences of activity. North of the Alaskan range no active volcanoes are at present known.

The transverse depressions of the mountainous continental border are occupied by rivers and continued as straits. Thus the Naas river, just south of the boundary, corresponds to the trough of Dixon Entrance and Portland Channel, the Stikine to that of Sumner Strait, the Taku to that of Cross Sound. The summit of the mountains at the head of Lynn Canal, situated about 15 miles from the sea, has an elevation of 2800 feet (White Pass) to 3500 feet (Chilkoot Pass); and here only, on the whole extent of the South-Eastern Alaskan coast, is a clear-cut watershed exhibited between the seaboard and interior drainage. Between the Alexander Archipelago and the peninsula of Alaska but few rivers make their way across the ranges to the sea, chiefly through difficult canyons. The Atna, or Copper river, is the most important of these and reaches the sea just east of Prince William Sound. At the head of Cook's Inlet a considerable valley is drained by the Knik (Fire) and Sushitna rivers. The latter rises in the Alaskan range. North-westward from the main axis of this range, especially towards the coast of Bering Sea, a number of large lakes exist, giving rise to rivers of some magnitude. West of Cook's Inlet, over the range, Lake Clark and Lake Iliamna feed the Kvichak river. Another assemblage of many smaller lakes is drained by the Nushagak river. Both empty into Bristol Bay. North of Cape Newenham Bering Sea receives the Kuskokwim, as yet hardly explored, but believed to have a length of 450 miles, chiefly through a rather mountainous country. Next northward, in latitude about 62° 30′, is the enormous delta of the Yukon, the chief river of Alaska and one of the great rivers of the world. It rises in British Columbia; the head of the branch called the Lewes river rising within 30 miles of the coast of Lynn Canal. Flowing in a north-westerly direction it cuts the Alaskan range, forming a canyon called the Upper Ramparts; a little later it receives the famous Klondike river from the north-east, and enters Alaska in about lat. 65° N. Just above the Arctic circle, near the site of old Fort Yukon, it turns to the south-west, passes through the canyon of the Lower Ramparts, receives from the south-east a large tributary, the Tananá; 175 miles farther down receives the Koyúkuk river from the northward, bends more to the southward, and in about lat. 62° N. turns again to the north-west and debouches through a vast delta into Bering Sea, south of Norton Sound. The total length of the unsurveyed Yukon has been estimated at 2000 miles; near the delta, in spring, one bank is not always visible from the other. It is navigable for steamers of light draft nearly to its headwaters, navigation opening early in June and closing in October. In the summer of 1899 thirty-five steamers were in active service on its waters. North of Bering Strait a number of rivers fall into the Arctic Sea: of these the most notable are the Selawik, Kowak, and Noatak of Kotzebue Sound; the Meade, Ikpikpung, and Colville of the Arctic coast.



Sketch Map of Alaska.

History.

The region now known as Alaska was first explored by the Russian officers Bering and Chirikoff in 1741. They visited parts of the coast between Dixon Entrance and Cape St Elias, and returned along the line of the Aleutians. Their expedition was followed by many private vessels manned by traders and trappers. Spanish expeditions in 1773 and 1775 visited the south-eastern coast and laid a foundation for subsequent territorial claims. Cook in 1778 made surveys from which the first approximately accurate chart of the coast was published; but it was reserved for Vancouver, in 1793-94, to make the first charts, in the modern sense, of the intricate south-eastern coast, which only in recent years have been superseded by new surveys. Owing to excesses committed by private traders and companies, the trade and regulation of the Russian possessions was in 1799 confided to a semi-official corporation called the Russian-American Company for a term of twenty years, afterward twice renewed for a similar period. Alexander Baránoff, one of the early administrators, became famous through the successes he achieved as governor. He founded Sitka, the present capital, in 1804, after the massacre by the natives of an earlier settlement at an adjacent point. In 1821 Russia attempted by ukase to exclude navigators from Bering Sea and the Pacific Coast of her possessions, which led to immediate protests from the United States and Great Britain. This led to a treaty with the United States in 1824 and one with Great Britain in 1825, by which the excessive demands of Russia were relinquished and the boundaries of the Russian possessions were fixed as at present. The last charter of the Russian-American Company expired 31st December 1861, and Prince Maksútoff, an imperial governor, was appointed to administer the affairs of the territory. In 1864 authority was granted to an American company to make explorations for a proposed Russo-American telegraph line overland from the Amur river in Siberia to Bering Strait, and through Alaska to British Columbia. Work was begun on this scheme in 1865 and continued for nearly three years, when the success of the Atlantic cable rendered the building of the line unnecessary and it was given up, but not until important explorations, especially of the Yukon region, had been made by Kennicott, Ketchum, Kennan, and Dall.

In 1867 negotiations with the Russian Government resulted in the purchase of Russian America by the United States for the sum of $7,200,000, and on 18th October 1867 the formal transfer of the territory was made in Sitka. In 1870 the fur seal industry of the Pribiloff Islands was leased for twenty years to the Alaska Commercial Company under certain restrictions, producing for that period an average revenue to the Government of $317,000. After the expiration of the lease in 1890 a renewal of the monopoly was secured by the North American Commercial Company at an increased rental. Pelagic sealing, which began to be of importance about 1882, made great inroads on the herds during their migrations; and it was contended that, owing to the killing of female seals in the waters of Bering Sea during the breeding season, the total destruction of this commercially valuable industry was imminent. After protracted negotiations between the United States and Great Britain the subject was referred to arbitrators, who met at Paris in 1893 and decided that the seals were *feræ naturæ*, but, in view of the interests involved, formulated regulations in the belief that they would mitigate the evils complained of.

In 1895 the discovery of rich deposits of gold on the Klondike tributary of the Yukon induced a vast immigration of prospectors, not only into British territory but into every part of Alaska, with the usual concomitants of hardship to those involved. Over 50,000 people are believed to have been engaged in this search for the precious metal, and a vigorous exploration of the territory by the United States Government was one of the results. Numerous placers were discovered in the gold belt, which extends in a general line from old Fort Selkirk on the Yukon to Bering Strait, with an average width of about 100 miles. The gold-bearing gravels are chiefly on the smaller tributaries of the Yukon, where numerous mining camps have sprung up with a fluctuating population. In 1898 gold was discovered on the north shore of Norton Sound at Cape Nome, and a year later the settlement of Anvil City in this district was reported to contain a population of 5000, and to have produced during 1899 nearly two millions of dollars.

Districts.

Alaska may be divided climatologically and topographically into several districts. The *Sitka district* takes its shore water mainly from the Japanese current or Kuro Siwo, which performs for the Pacific such a function as does the Gulf Stream for the Atlantic; but owing to the much greater breadth of the Pacific, the heat and energy of the Kuro Siwo are greatly depleted before it reaches America. It crosses the ocean far south of the Aleutian Islands in about lat. 45° N. and impinges on the American coast near Queen Charlotte Islands. Thence one portion turns southward and the other northward and westward along the coast, becoming finally dissipated among the Fox Islands. To the warmth and moisture brought by this means the Sitkan district owes its fog and rain (80 to 103 inches per annum), its high mean temperature (43°·28), and its dense vegetation, chiefly of spruce, hemlock, and cedar. The narrow, deep channels, precipitous wooded slopes, multitudinous islands, and mainland glaciers make this district remarkably picturesque and characteristic, attracting thousands of tourists. It is inhabited by Indians of the Haida and Tlinkit stocks, who live chiefly by fishing and hunting. The principal settlements are Sitka on Baránoff Island, the capital of Alaska, where the chief officials are stationed; Douglas, on Douglas Island, a town grown up about the mines of the Treadwell lode, an enormous mass of low grade ore, reduced by mills of 800 stamps and producing nearly $1,000,000 per annum; Juneau, on the mainland opposite, another mining town fed by the precious metals of the Silver Bow basin adjacent; and Skagway, at the head of Lynn Canal, the port of entry for the Yukon, which is reached by the Yukon and White Pass Railway from Skagway to Lake Bennett, in Canadian territory. A missionary colony on Annette Island, under the direction of the Rev. Mr Duncan, contains about 900 Indians of the Tsimpsyan stock from British Columbia, and is famous for its thrift and successful influence upon these people. Agriculture is difficult in this district, but potatoes and many garden vegetables are successfully grown. The *Kadiak district* includes Cook's Inlet, the peninsula of Alaska, and the Kadiak islands. It is less densely wooded, with more sunshine, less rain, and greater seasonal extremes of temperature. There is more arable land and the possibilities of agriculture are greater, but the mining resources apparently less. The district exists by its salmon fisheries, the waning fur trade, a few placer and quartz mines, and a little agriculture. There are large deposits of tolerably good Eocene lignite. The principal settlements are Sunrise City, a placer mining camp at the head of Turnagain arm of Cook's Inlet; St Paul, on Kadiak Island; and Unga, on the island of the same name, largely supported by the Apollo Mine, the second best quartz mine in Alaska, producing over $200,000 in gold annually. The *Aleutian district* derives its name from traditions of islands beyond the Olintorsk Cape of Kamchatka, which related to the Diomedes. When the Russians explored Bering Sea and found the Catherina Archipelago they transferred to it and its people the name of the long-sought Oliutorski Islands. The islands are destitute of trees but covered by a luxuriant growth of herbage, and have a foggy, somewhat boisterous, but less rainy climate than that of Sitka, with about the same mean temperature, very free from extremes. They are inhabited by the Uuñgun (long known as Aleuts), a rapidly-decreasing race, half civilized, with many virtues and the usual aboriginal weaknesses. Their chief resource, the sea otter, is nearly exterminated, the fur seal industry in a state of decline, and the people live chiefly by fishing. There are no native land animals larger than the blue fox; but sea fowl are remarkably abundant, cod and other sea fish plentiful, and salmon obtainable in moderate quantity.

Agriculture is hardly practised, though a few vegetables are raised. The raising of sheep and reindeer is believed to be practicable on the less mountainous islands. The chief settlements are on Unaláshka Island, where Dutch Harbour is the principal port for Bering Sea commerce; Atka, on the island of the same name; and the small settlement of Attu, at the western extreme of the chain. The *Yukon district*, which may be taken as the vast region north-westward from the Alaskan mountains, has a colder and drier climate than those above mentioned, passing northward into Arctic conditions. The immediate shores are treeless, but the interior is fairly well wooded with spruce, poplar, and birch along the water-courses. The inhabitants of the coasts are Eskimo, of the interior Tinneh, or Athabaskan Indians. The search for gold has brought into the valley of the Yukon and its tributaries a large population of prospectors. The residents depend for substance chiefly upon salmon and white fish, with which the rivers swarm; wild fowl, which are very abundant; and the continental mammals, chief of which is the wild caribou. Mining for placer gold is the only industry, the fur trade being now unimportant, and there are few salmon canneries. The chief port for the Yukon is St Michael, on Norton Sound, though a large mining camp, called Anvil City, has been established at Cape Nome, on the north shore of the sound.

Though forming what is called a judicial and customs district, Alaska is still an unorganized territory, with a governor and some other officials appointed by the president. Since 1884 the people have vigorously worked for the extension of law and the organization of some kind of official system throughout the territory. Until recently these efforts have been but partially successful, but in 1900 a code for the administration of the territory under improved conditions became law. The total population in 1890 was 32,052, of whom 23,531 were natives, 1823 of mixed blood, and 4298 white. Of the natives 6000 were of Haida, Tsimpsyan, and Tlinkit stock; 3400 of the Tinneh tribes, 1000 Aleuts, and 13,100 Eskimo. The annual diminution of the native population (1880-90) was about 2 per cent., and of late the rate is believed to be much more rapid. It is estimated that the white population was in 1900 about 32,000.

The products of the territory have fluctuated with the decline of certain industries and the rise of others. In 1890 they were as follows:—

Fur seal	yearly average for ten years	value	$1,744,200
Other fur		,,	628,400
Salmon (cases tinned, 642,175)		,,	2,568,700
,, (salted, 18,039 barrels)		,,	162,351
Cod (salted, 760 tons)		,,	38,000
Whale oil (12,503 barrels)		,,	116,250
Whalebone (231,981 ℔)		,,	463,962
Walrus ivory (5799 ℔)		,,	3,000
Gold		,,	4,604,500
Silver		,,	27,340

The value of gold produced by the territory in 1899 is calculated by the director of the United States Mint to be $4,610,000, and of silver $258,585. The fur seal skins taken in 1887 on the Pribiloff Islands numbered 106,000; those taken by the pelagic sealers, 20,628. In 1897 the Pribiloffs could furnish only 19,200, while the pelagic catch was 24,321. The continental fur trade is waning, and, owing to competition, less profitable than formerly. The whale fishery, now carried on only for the baleen, as there is no profit on the oil, is reduced to eight vessels. The salmon and cod fisheries are reasonably prosperous. Mining has taken a great stride in advance, especially for the precious metals, and the prospect of valuable copper mines in the Prince William Sound region is believed to be good.

See Whymper. *Travels in Alaska and on the Yukon*, 1868.—Dall. *Alaska and its Resources*, 1870.—Bancroft. *History of Alaska*, 1886.—Shepard. *Cruise of the "Rush,"* 1889.—U.S. Senate ex. doc. 146. *Report on the Boundary line between Alaska and British Columbia*, 1889.—Wellcome. *The Story of Metlakahtla*, 1887.—Scidmore. *Alaska and the Sitkan Archipelago*, 1885.—U.S. Coast Survey. *Meteorology and Bibliography of Alaska*, 1879; *Coast Pilot of Alaska*, 1883.—U.S. Geological Survey (Dall)—*Coal and Lignite of Alaska*, 1896; (Becker)—*Goldfields of Southern Alaska*, 1898; *Map of Alaska, with descriptive text*, 1898.—Dall. *Remains of Prehistoric Man in Alaska*, 1878; *Tribes of the Extreme North-West*, 1877; *Alaska as it was and is*, 1895.—U.S. State Department (D. S. Jordan)—*Fur Seals and Fur Seal Islands of the North Pacific*, 1898-99.

(W. H. D.)

Ala-tau (*Variegated Mountains*) is the name of three different mountain ranges in the Russian dominions in Asia: (1) the Kuznetsk Ala-tau is on the frontiers of Tomsk and Yeniseisk (*q.v.*); (2) the Dzungarian Ala-tau is in the province of Semiryechensk (*q.v.*); and (3) the Trans-Ili Ala-tau is in Turkestan (*q.v.*).

Alatyr, a district town of Russia, in the government and 107 miles N.W. of Simbirsk, on the Sura, a tributary of the Volga, in steamer communication with Vasilsursk on the Volga, and by rail with Kazañ (153 miles). It does considerable trade in corn and has some historically important monasteries. Population (1897), 11,090. The important river port of Promzino Gorodische (4350) is in its district.

Alava, a province in the north of Spain—one of the Spanish Basque Provinces, *q.v.*—with an area of 1200 square miles. The countship of Trevino (190 square miles), in the centre of the province, belongs to the province of Burgos. Population (1897), 94,642. There are two administrative districts and eighty-five parishes. Few provinces in Spain are inhabited by so laborious, active, and well-to-do a population. The primary schools are numerously attended, and there are very good normal schools for teachers of both sexes, and a model agricultural farm. The public roads and other works of the province are excellent, and, like those of the rest of the Basque provinces, entirely kept up by local initiative and taxes. Railways from Madrid to the French frontier, and from Castejon to Bilbao, both cross this province. The climate is mild in summer, fitful in autumn and spring, and very cold in winter, as even the plains are a high plateau surrounded on three sides by mountains always snowclad during several months. Asphaltic stone is quarried, and there are mineral waters at many places. The local industries are of some importance since 1880—foundries, manufactures of beds, furniture, railway carriages, matches, paper, sweets, woollen and cotton goods. Breadstuffs, colonial products, machinery are largely imported. The live stock in the province includes 7552 horses, 2844 mules, 1447 donkeys, 22,716 cattle, 68,066 sheep, 14,614 goats, and 21,355 pigs. Wheat is grown on 49,955 acres; oats, barley, rye, and maize on 28,075; vines on 36,000; and olives on 1795. Only four mines are actually worked; lead, blende, and lignite are produced.

Albacete, a province in the S.E. of Spain, with an area of 5971 square miles. Population (1897), 233,005. It is divided into eight districts and eighty-three parishes. The state and provincial roads are not in very good condition, and the municipal ones are worse. The climate is temperate in the mountainous parts of the Jurre Alcaraz district and in lower regions, but it is cold for months in the ranges that have peaks several thousand feet high; the rich and fertile valleys and some plains are most thickly peopled. The live stock in the province includes 1987 horses, 16,461 mules, 15,252 donkeys, 2410 cattle, 187,853 sheep, 50,687 goats, 22,113 pigs. Wheat is grown on 342,415 acres, other cereals on 249,500 acres, vines on 98,630, and olives on 26,738. Two salt-mines are worked, and there are important lagoons.

Albacete, the capital of the above province, has a station on the Madrid–Alicante line. Modern erections are, besides other buildings, the town hall, courts of justice, barracks, and provincial council palace. There are an institute, schools for teachers of both sexes, seven municipal and fifteen private schools. Matches are included in the manufactures. The population was 18,589 in 1887, and 21,637 in 1897.

ALBANIA.

ALBANIA, a portion of the Turkish Empire extending along the western littoral of the Balkan peninsula from the southern frontier of Montenegro to the northern confines of Greece, is perhaps the least known region in Europe; and though more than a hundred years have passed since Gibbon described it as "a country within sight of Italy, which is less known than the interior of America," but little progress has yet been made towards a scientific knowledge of this interesting land and its inhabitants. The wild and inaccessible character of the country, the fierce and lawless disposition of the people, the difficulties presented by their language and their complex social institutions, and the inability of the Turkish authorities to afford a safe conduct in the remoter districts, combine to render Albania almost a *terra incognita* to the foreign traveller, and many of its geographical problems still remain unsolved. The region of the Mirdites, the Mat district, the neighbourhood of Dibra, and other localities have never been thoroughly explored. The northern boundary of Albania has undergone some alteration in consequence of the enlargement of Montenegro, sanctioned by the Berlin Treaty (13th July 1878); owing to subsequent arrangements providing for the cession of Dulcigno to Montenegro (25th November 1880) in exchange for the districts of Plava and Gusinye, restored to Turkey, the frontier-line (finally settled December 1884) now ascends the Boyana from its mouth to Lake Sasa, thence passes northward, and crossing Lake Scutari separates the district of Kushka Kraina on the N. from the territories of the Hot and Klement tribes on the S.; leaving Gusinye and Plava to the S.E., it turns to the N.W. on reaching the Mokra Planina, and then follows the course of the Tara river. On the S., Albanian territory has been curtailed owing to the acquisition of the Arta district by Greece (May 1881), the river Arta now forming the frontier. On the E. the chains of Shar, Grammos, and Pindus constitute a kind of natural boundary which does not, however, coincide with ethnical limits, nor with the Turkish administrative divisions. Albania is inhabited by six different races: Albanians (who form the great majority), Serbs, Bulgars, Greeks, Vlachs, and Turks, together with an inconsiderable number of gypsies and Jews. The larger portion of the interior is occupied by a fairly compact Albanian population. Since about the year 1870 there has been a remarkable advance of the Albanians in a north-easterly direction towards Prishtina, Vrania, and Usküb, the invaders inflicting much injury on the Serb and Bulgar inhabitants. Servian settlements exist in various parts of Northern Albania; there is a strong Bulgarian colony in the neighbourhood of Dibra and Ochrida; farther south, Mount Zygos and the Pindus range—the "Great Wallachia" of the middle ages—are inhabited by Vlakhs or *Tzintzars;* several Turkish settlements are found in the south-eastern districts, while in Southern Epiros there is a large admixture of the Greek element. North-western Albania forms part of the Turkish vilayet of Kossovo; the northern highlands are included in the vilayet of Shkodra (Scutari), the eastern portion of Central Albania belongs to the vilayet of Monastir, and the southern districts are comprised in the vilayet of Iannina. The boundaries of the three last-named vilayets meet near Elbassan. The name Albania (in the Tosk dialect *Arbería*, in the Gheg *Arbenía*), like Albania in the Caucasus, Armenia, Albany in Britain, and Auvergne (*Arvenia*) in France, is probably connected with the root *alb*, *alp*, and signifies "the white or snowy uplands."

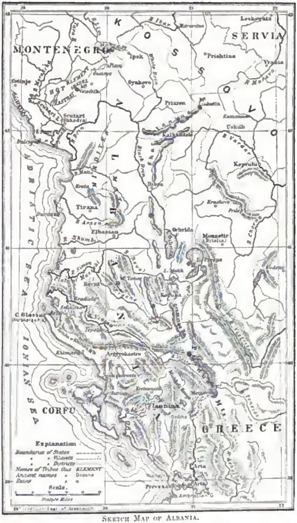
Physical features.

The mountain system is extremely complex, especially that of the northern region. On the E. the great Shar range, extending in a south-westerly direction from the neighbourhood of Prishtina to that of Dibra, is continued towards the S. by the ranges of Grammos and Pindos: the entire chain, a prolongation of the Alpine systems of Bosnia and Dalmatia, may be described as the backbone of the peninsula; it forms the watershed between the Aegean and the Adriatic, and culminates in the lofty peak of Liubotrn, near Kalkandele, the highest summit in South-Eastern Europe (3050 metres). The country to the W. of this natural barrier may be divided geographically into three districts—Northern, Central, and Southern Albania. The river Shkumb separates the northern from the central district, the Viossa the central from the southern. The highland region of Northern Albania is divided into two portions by the lower course of the Drin; the mountains of the northern portion, the Bieska Malziis, extend in a confused and broken series of ridges from Scutari to the valleys of the Ibar and White Drin; they comprise the rocky group of the Prokletia, or Accursed Mountains, with their numerous ramifications, including Mount Velechik, inhabited by the Kastrat and Shkrel tribes, Bnkovik by the Hot, Golesh by the Klement, Skulsen (2296 metres), Baba Vrkh (about 2227 metres), Maranazh near Scutari, and the Bastrik range to the E. South of the Drin is another complex mountain system, including the highlands inhabited by the Mirdites and the Mat tribe; among the principal summits are Deia Mazzuklit, Mal-i Velesh, Kraba, and Toli. Central Albania differs from the northern and southern regions in the more undulating and less rugged character of its surface; it contains considerable lowland tracts, such as the wide and fertile plain of Musseki, traversed by the river Simen. The principal summit is Tomor (2413 metres), overhanging the town of Berat. Southern Albania, again, is almost wholly mountainous, with the exception of the plains of Iannina and Arta; the most noteworthy feature is the rugged range of the Tchika, or Khimara mountains, which skirt the sea-coast from S.W. to N.E., terminating in the lofty promontory of Glossa (ancient *Akrokeraunia*). Further inland the Mishkeli range to the N.E. of Lake Iannina and the Nemertzika mountains run in a parallel direction. In the extreme S., beyond the basin of the Kalamas, the mountains of Suli and Olyzika form a separate group. The rivers, as a rule, flow from E. to W.; owing to the rapidity of their descent none are navigable except the Boyana and Arta in their lower courses. The principal rivers are the Boyana, issuing from Lake Scutari, and consequently regarded as a continuation of the Montenegrin Moratcha, the Drin, formed by the confluence of the White and Black Drin, which flowing respectively to the S. and N. through a long valley at the foot of the Shar range, take a westerly direction after their junction, the Matia, the Arzen, the Shkumb (anc. *Genusos*), the Simen (anc. *Apsos*), formed by the junction of the Devol and Ergene, the Viossa (anc. *Aous*), which owing to the trend of the Chimara range takes a north-westerly direction, the Kalamas (anc. *Thyamis*), and the Arta (anc. *Arachthos*), flowing S. into the Ambracian Gulf. A portion of the stream of the Drin has recently found its way into the Boyana channel; the result has been a rise in the level of Lake Scutari and the inundation of the adjacent lowlands. A proposal to confine the Drin to its former course by means of a dyke, and to ease the downflow of the Boyana by a canal opening navigation to Lake Scutari, has long been considered by the Turkish authorities. The great lakes of Scutari (350 sq. kil.) and Ochrida (270 sq. kil.) are among the most beautiful in Europe; the waters of the latter, which find an outlet in the Black Drin, are of marvellous clearness. Lake Malik, to the S.W. of Ochrida, is drained by the Devol. The waters of the picturesque Lake Iannina (61 sq. kil.) find an issue by *katabothra*, or underground channels, into the Ambracian Gulf. The lake of Butrinto (anc. *Buthrotum*) is near the sea-coast opposite Corfu.

The climate is healthy in the uplands, though subject to violent changes; in the valleys fever is very prevalent, especially in the basins of the Boyana, the lower Drin, and the Simen. The winter is short, but exceedingly cold; snow remains on the Prokletia and other mountains till August, and sometimes throughout the year. The summer temperature in the plains is that of southern Italy; in the mountain districts it is high during the day, but falls almost to freezing-point at night. The sea-coast is exposed to the fierce *bora*, or north wind, during the spring.

Natural products.

The mountains of Albania are said to be rich in minerals, but this source of wealth remains practically unexplored. Iron and coal are probably abundant, and silver-lead, copper, and antimony are believed to exist. Gold mines were worked in antiquity in the Drin valley, and silver mines in the Mirdite region were known to the Venetians in the middle ages. At Selinitza, near Avlona, there is a remarkable deposit of mineral pitch which was extensively worked in Roman times; mining operations are still carried on here, but in a somewhat primitive fashion. The splendid forests, of which there are 70,000 square acres in the vilayet of Scutari alone, are undergoing a rapid process of destruction, as in other lands under Turkish rule. The principal trees are the oak, the valonia oak, the beech, ash, elm, plane, celtis, poplar, and walnut, which give way in the higher regions to the pine and fir. The oak forests near Dibra, where charcoal-making is a considerable industry, and the beechwoods of the Prishtina district, are especially remarkable.



SKETCH MAP OF ALBANIA.

The sumach is largely grown in the Mirdite district; its leaves are exported to Trieste for use in tanneries and dyeworks. In 1898 the export of valonia was estimated at 280,000 francs, of sumach at 60,000 francs. Of fruit-trees the white mulberry, cherry, and wild pear are plentiful; the chestnut and walnut are sometimes met with, and the olive is grown in the lowland and maritime districts. The exportation of olive oil in 1898 was valued at 600,000 francs. The greater part of the country is admirably suited to viticulture, and wine of tolerable quality is produced. Tobacco is grown extensively in Southern Albania, especially near Berat and in the upper valley of the Viossa, but the quantity exported is small. The means of subsistence are mainly provided by the cultivation of grain and cattle-rearing. Notwithstanding the primitive condition of agriculture, the deficiency of communications, and the damage caused by frequent inundations, Albania furnishes almost the entire corn supply of the Dalmatian coast and islands. Maize is the favourite grain for home consumption, but considerable quantities of this cereal, as well as barley, rye, and oats, are exported. The total export of cereals in 1898 was valued at 1,770,000 francs. Sheep and goats form almost the only wealth of the mountaineers of Northern Albania; large cattle are found only on the plains. The slopes of Pindos afford excellent pasture for the flocks of the Vlakh shepherds. The export of raw hides and wool is considerable; the former was estimated in 1898 at 2,260,000 francs, the latter at 600,000 francs. The lakes and rivers of Albania abound in fish. The *scoranze*, a kind of sardine, is taken in great quantities in Lake Scutari; it is salted and smoked for home consumption and exportation. Sea fishing is almost wholly neglected. There are salines at Avlona and other places on the coast.

Commerce and industries.

The exports in 1898 were estimated at 12,000,000 francs, the imports at 34,000,000 francs, the former comprising agricultural produce, live stock, hides, wool, cheese, eggs, poultry, olive oil, valonia, sumach leaves, timber, skins of wild animals, silk, tobacco, and salted fish, the latter manufactured articles, cloth, hardware, furniture, firearms, gunpowder, sugar, coffee, etc. The monopoly of Albanian commerce formerly possessed by Venice has descended to Austria-Hungary; the trade with other countries, except Italy, is inconsiderable. Owing to the poverty of the people, cheap Austrian goods find a readier sale than the more expensive and solid British manufactures. The maritime traffic is largely conducted by the steamers of the subsidized Austrian-Lloyd company, Trieste being the principal commercial centre; the coasting trade is carried on by small Greek and Turkish sailing vessels. The trade of the northern and western districts has to some extent been diverted to Salonika since the opening of the railways from that town to Mitrovitza and Monastir. The development of commerce is retarded by lack of communications; the country possesses no railways and few roads. Several railway lines have been projected, but there is no great probability of their construction under existing political conditions. The Via Egnatia, the great Roman highway to the east, is still used; it runs from Durazzo (*Dyrrhachium*) to Elbassan and Ochrida. Iannina is connected by carriage-roads with Monastir, Agii Saranta, and Preveza. As a rule, however, bridle-paths supply the only means of communication. The native industries are inconsiderable, and many of them are in a languishing condition. The manufacture of highly ornate firearms, yataghans, and other weapons at Scutari, Gyakovo, and Prizren has declined, owing to the importation of modern rifles and revolvers. Gold and silk embroidery, filigree work, morocco, and richly-braided jackets are produced for home use and for sale in Bosnia, Macedonia, and Montenegro.

Population.

The population of Albania may be estimated at between 1,600,000 and 1,500,000, of whom 1,200,000 or 1,100,000 are Albanians. Of the other races the Slavs (Serbs and Bulgars) are the most numerous, possibly numbering 250,000. There is a considerable Greek-speaking population in Epiros (including many Mahommedan Albanians), which must, however, be distinguished from the genuine Greeks of Iannina, Preveza, and the extreme south; the latter may be estimated at 100,000. The Vlakhs, mainly in the Pindos district, possibly number 70,000. The population of the vilayet of Scutari is given as 322,000, or 28 per square kilometre; that of the vilayet of Iannina as 648,000, or 33 per square kilometre. The principal towns are Scutari (Albanian *Shkóder*, with the definite article *Shkóder-a*), the capital of the vilayet of that name, pop. 37,000; Prizren, 30,000; Iannina (often incorrectly written *Ioannina*), capital of the southern vilayet, 25,000; Gyakovo, 25,000; Dibra, 20,000; Ipek (Slav. *Petch*), 15,000; Berat, 15,000; Ochrida, 15,000; Tirana, 12,000; Argyrokastro, 11,000; Kortcha (Slav. *Goritza*), 10,000; Elbassan, (perhaps anc. *Albanopolis*), 8000; Metzovo, 7500; Préveza, 6500; and Kroia, the ancient fortress of Skanderbeg, 5000.

The Albanians are apparently the most ancient race in South-Eastern Europe. History and legend afford no record of their arrival in the Balkan peninsula. They are probably the descendants of the earliest Aryan immigrants, who were represented in historical times by the kindred Illyrians, Macedonians, and Epirots; the Macedonians and Epirots are believed by Hahn to have formed the core of the pre-hellenic Tyrrheno-Pelasgian population which inhabited the southern portion of the peninsula and extended its limits to Thrace and Italy. The Illyrians were also "Pelasgian," but in a wider sense. Of these cognate races, which are described by the Greek writers as barbarous or non-hellenic, the Illyrians and Epirots, he thinks, were respectively the progenitors of the *Ghegs*, or northern, and the *Tosks*, or southern, Albanians. The Via Egnatia, which Strabo (vii. fragment 3) describes as forming the boundary between the Illyrians and Epirots, practically corresponds with the course of the Shkumb, which now separates the Ghegs and the Tosks. The same geographer (v. 2, 221) states that the Epirots were also called Pelasgians; the Pelasgian Zeus was worshipped at Dodona (Homer, *Il.* xvi. 234) and the neighbourhood of the sanctuary was called Pelasgia (Herodotus, ii. 56). The name *Tosk* is possibly identical with *Tuscus*, *Etruscus*, while the form *Tyrrheans* perhaps survives in Tirana. The large number of Slavonic local names in Albania, even in districts where no trace of a Slavonic population exists, bears witness to an extensive Servian or Bulgarian immigration in the early middle ages, but the original inhabitants appear to have gradually ousted the invaders. The determination with which this remarkable race has maintained its mountain stronghold through a long series of ages has hitherto met with scant appreciation in the outside world. While the heroism of the Montenegrins has been lauded by writers of all countries, the Albanians—if we except Byron's eulogy of the Suliots—still *carent vate sacro*. Not less noticeable is the tenacity with which isolated fragments of the nation have preserved their peculiar characteristics, language, customs, and traditions. The Albanians in Greece and Italy, though separated for six centuries from the parent stock, have not yet been absorbed by the surrounding populations.

The Albanians, both Ghegs and Tosks, call themselves *Shkyipetar*, and their land *Shkyipenia* or *Shkyiperia*, the former being the Gheg, the latter the Tosk form of the word. *Shkyipetar* has been variously interpreted. According to Hahn it is a participial from *shkyipoy* "I understand," signifying "he who knows" the native language; others interpret it as "the rock-dweller," from *shkep*, *shkip*, "rock." The designations *Arber* (Greek Αρβανίτης, Turkish *Arnaout*) denoting the people, and *Arbenía* or *Arbería* the land, are also, though less frequently, used by the Albanians. The Tosk form *Arbería* strictly applies only to the mountain district near Avlona. The region inhabited by a more or less homogeneous Albanian population may be roughly marked out by a line drawn from the Montenegrin frontier at Berane to Leskovatz in Servia, thence to Vrania, Uskub, Prilep, Monastir, Florina, Kastoria, Iannina, and Parga. These limits, however, are far from including all the members of a widely-scattered race. The Albanians in Greece, whose settlements extend over Attika, Bœotia, the district of Corinth, and the Argolid peninsula, as well as Southern Eubœa and the islands of Hydra, Spetzæ, Poros, and Salamis, descend from Tosk immigrants in the 14th century. They played a brilliant part in the war of independence, and to-day supply the Greek army with its best soldiers. They were estimated by Leake at 200,000. A large number still speak the Albanian language; many of the older men, and a considerable proportion of the women, even in the neighbourhood of Athens, are ignorant of Greek. The Albanian settlements in Southern Italy and Sicily were founded in

1444, 1464, and 1468; minor immigrations followed in the three succeeding centuries. In Southern Italy there are 72 Albanian communes, with 154,674 inhabitants; in Sicily 7 communes, with 52,141 inhabitants. The Italian and Sicilian Albanians are of Tosk descent, and many of them still speak a variation of the Tosk dialect. There are also several Albanian settlements in European Turkey and Asia Minor, some founded by military colonists who received grants of land from successive sultans, others owing their origin to enforced migrations after insurrections in Albania. The only genuine division of the Albanian race is that of Ghegs and Tosks; the Liaps, who inhabit the district between the Viossa and the sea, and the Tshäms or Chäms, who occupy the coast-land south of the Kalamas, are subdivisions of the Tosk family. The name Gheg (*Gegë-a*) is not adopted by the Ghegs themselves, being regarded as a nickname; the designation Tosk (*Toskë-a*) is restricted by the Tosks to the inhabitants of a small region north of the lower Viossa (Toskeria).

National characteristics.

While the other primitive populations of the peninsula were either hellenized or latinized, or subsequently absorbed by the Slavonic immigration, the Albanians to a great extent remained unaffected by foreign influences. Retaining their original language and preserving the customs and institutions of remote antiquity, they present a distinct type, and differ in many essential particulars from the other nations of the peninsula. The Ghegs, especially, notwithstanding their fierce and lawless character, their superstition, ignorance, and predatory propensities, possess some noteworthy qualities rarely found in Eastern Europe: simple, brave, faithful, and sometimes capable of devoted attachment, these wild mountaineers make excellent soldiers and trustworthy retainers; they have long furnished a bodyguard to the sultan, and are much employed as kavasses and attendants at foreign embassies and consulates in the East. The native disposition of the Tosks has been modified by intercourse with the Greeks and Vlakhs; while the Gheg devotes his attention exclusively to fighting, robbery, and pastoral pursuits, the Tosk occasionally occupies himself with commercial, industrial, or agricultural employments; the Gheg is stern, morose, and haughty, the Tosk lively, talkative, and affable. The natural antipathy between the two sections of the race, though less evident than in former times, is far from extinct. In all parts of Albania the vendetta (*gyäk*) or blood-feud, the primitive *lex talionis*, is an established usage; the duty of revenge is a sacred tradition handed down to successive generations in the family, the village, and the tribe. A single case of homicide often leads to a series of similar crimes or to protracted warfare between neighbouring families and communities; the murderer, as a rule, takes refuge in the mountains from the avenger of blood, or remains for years shut up in his house. It is estimated that in consequence of these feuds scarcely 75 per cent. of the population die a natural death. A truce (*bessa*: literally "faith, pledge"), either temporary or permanent, is sometimes arranged by mediation or, among the Ghegs, by the intervention of the clergy; a general *bessa* has occasionally been proclaimed by special iradé of the sultan, the restoration of peace being celebrated with elaborate ceremonies. So stringent are the obligations of hospitality that a household is bound to exact reparation for any injury done to a guest as though he were a member of the family. No traveller can venture into the mountain districts without the *bessa* of one of the inhabitants; once this has been obtained he will be hospitably welcomed. In some districts there is a fixed price of blood; at Argyrokastro, for instance, the compensation paid by the homicide to the relatives of his victim is 1200 piastres (about £10), at Khimara 2000 piastres; once the debt has been acquitted amicable relations are restored. Notwithstanding their complete subjection, women are treated with a certain respect, and are often employed as intermediaries in the settlement of feuds; a woman may traverse a hostile district without fear of injury, and her *bessa* will protect the traveller or the stranger. Women accompany their male relatives to the battlefield for the purpose of tending the wounded and carrying away the dead. The bride brings no dowry to her husband; she is purchased at a stipulated price, and earnest-money is paid at the betrothal, which usually takes place while the contracting parties are still children. It is customary for young men who are attached to each other to swear eternal brotherhood (compare the Slavonic *pobratimstvo*); the contract is regarded as sacred, and no instance has been known of its violation. The costume of the Tosks differs from that of the Ghegs; the distinctive feature of the former is the white plaited linen fustanella or petticoat, which has also been adopted by the Greeks; the Ghegs wear trews of white or crimson native cloth adorned with black braid, and a short, close-fitting jacket, which in the case of wealthy persons is embellished with gold lace. The fez is worn by both races, and in the northern highlands yataghans and firearms are almost invariably carried. The costume of the Mirdite and Mat tribes is peculiar. It consists of a sheepskin cap, a long white tunic bound with a red girdle, white linen trousers, and opinki, or sandals.

Tribal system.

The tribal organization in Northern Albania is an interesting survival of the earliest form of social combination; it may be compared in many respects with that which existed in the Scottish highlands in the time of the Stuart kings. The practical autonomy which the Gheg mountaineers enjoy has been won by a prolonged and successful resistance to Turkish domination; as a rule they pay no taxes, they are exempt from the conscription, they know nothing of the Ottoman law, and the few Turkish officials established amongst them possess no real authority. Their only obligation to the Turkish government is to furnish a contingent in time of war; the only law they recognize is either traditional custom (*adét*) or the unwritten *Kanun-i Leks Dukajinit*, a civil and criminal code, so called from its author, Leka Dukajini, who is supposed to have lived in the 13th or 14th century. The tribe or *mal* ("mountain") is often composed of several clans (*phis-i*, *phárea*) or *baryaks* (literally "standards") each under a chief or *baryaktar* (standard-bearer), who is, strictly speaking, a military leader; there are in each clan a certain number of elders or voivodes (Albanian *krü-ye*, pl. *krene-te*) who form a council and, like the baryaktar, hold their office by hereditary right; they preside over the assemblies of the tribesmen, which exercise the supreme legislative power. The clan is generally subdivided into smaller communities (*mahalë*), each administered by a local notable or *gyobar*. The gyobars superintend the execution of the laws, collect fines, and administer capital punishment; they are in contact with the *buluk-pashi*, or resident representative of the tribe at Scutari, who forms the only link between the mountaineers and the Turkish government. He communicates to the tribesmen the orders of the Vali, which must be framed in accordance with their customs and institutions. The tribes of Northern Albania, or Ghegeria, may be classified in seven groups as follows:—(1) The Mirdites, who inhabit the alpine region around Orosh to the south-east of Scutari—the most important of all in respect of numbers (about 26,000) and political independence. A Catholic tribe, occupying an inaccessible district, they have hitherto defeated every effort of the Turks to encroach on their autonomy. Their hereditary chiefs, or *capidans*, belong to the family known as *Dera e Gyon Markut* (the house of John Marco) which is said to be descended from Skanderbeg. In 1868 the reigning chief, Bib Doda, died, and his son and successor Prenk was detained as a hostage by the Turks. The Mirdites consequently refused to contribute their customary contingent to the Turkish army, and eventually Prenk was restored. His ambiguous conduct, however, led to the despatch of two expeditions against the Mirdites and the devastation of their territory. In 1880 Prenk was kidnapped by the Turkish authorities and exiled to Anatolia; another member of the ruling family was appointed kaimakan, but the Mirdites refused to obey him, and their district has ever since been in a state of anarchy. No Moslem is allowed to remain in Mirdite territory. (2) The Mi-shkodrak (Upper Scutari) group or confederation, also known as the Malsia-Madhé (Great Highlands) is composed of the Klement, Grud-a, Hot, Kastrat, and Shkrel tribes, which occupy the mountainous district north-east of Scutari. Owing to the proximity of the capital this group is comparatively subject to the Turkish power, and pays a small annual tribute; the chiefs, who assess and collect the tribute, form a kind of administrative council; the confederation has also an official representative council at Scutari, called the *Jibal*, under the presidency of a *Serkardë* or Moslem official. (3) The Dukajin, whose territory lies between that of the last-named group and the Mirdite country, include the Pulati, Shalla, Shoshi, and other tribes; they are more independent and more savage than the Mi-shkodrak, and have never paid tribute from time immemorial. (4) The Puka group, known as "the Seven Baryaks of Puka," dwell farther to the east; they are nominally administered by a Turkish kaimakam, who is a mere spectator of their proceedings. (5) The Malsia Gyakovs, a group of two Catholic and three Moslem tribes, extend in the direction of Gyakovo, where they maintain an official representative; they are entirely exempt from taxation. (6, 7) The Malsia-Lezhs, who occupy the Alessio highlands, and the Malsia Krues, who inhabit the region north of Kroia, live in a state of extreme poverty and pay no tribute; the latter are much addicted to brigandage. To these seven groups, which are included under the general appellation of *Malissori*, or "highlanders," may be added the Malsia of Dibra, who extend to the west and north of that town, and form a large separate group; they are notorious for their fierce lawless character, and maintain themselves by plundering the Bulgarian peasants in their neighbourhood. In general the attitude of the Albanians in the north-western districts towards the Slavonic peasantry may be compared with that of the Kurds towards the Armenians. In Central Albania the Mat tribe, which occupies the upper valley of the Matia, presents an entirely different organization; their district is governed by four wealthy families possessing hereditary rank and influence. Towards the south the tribal organization becomes looser and is gradually supplanted by a kind of feudal system; among the powerful aristocratic houses may be mentioned the Vliores at Avlona, who are stated to own 400 square kilometres of land, and the Toptans at Tirana. The principal landowners, who reside in fortified houses, are all Moslems; their estates are cultivated on the *metayer* system. Since the time of Ali Pasha, who broke the power of the local chieftains, Southern Albania has been subject to the central Turkish power; before that period the mountaineers of Suli and Khimara enjoyed an independence similar to that of the Gheg tribes.

Religions.

The great majority of the Albanians, probably more than three-fifths, are Moslems. The conversion of the Christian population to Islam appears to have taken place during the 16th and 17th centuries. Like the Cretan Moslems and the Bulgarian Pomaks, the Albanian Mahommedans retain many Christian traditions and customs; it is said that many thousands of them secretly adhere to their original faith. In the vilayet of Scutari they form more than 60 per cent. of the population; Central Albania is almost entirely Moslem; in Southern Albania, however, there is a considerable Christian population, whose limits practically coincide with those of the Greek-speaking districts. Of the Christian Albanians (about 480,000) some 100,000 are Catholics, almost all belonging to the Gheg tribes of the north; the remainder, including a small proportion of the Tosks, and nearly all the Greeks, Slavs, and Vlakhs, are of the Orthodox Church. The Catholic Ghegs appear to have abandoned the Eastern for the Western Church in the middle of the 13th century. Their bishops and priests, who wear the moustache in deference to popular prejudice, are typical specimens of the church militant. Some of the Gheg tribes, such as the Puka, Malsia, Gyakovs, and Malsia Krues, are partly Catholic, partly Moslem; among fellow-tribesmen the difference of religion counts for little. The Mirdites are exclusively Catholic, the Mat-i exclusively Moslem. At the head of the Catholic hierarchy are the archbishops of Scutari (with three suffragans), Prizren, and Durazzo; the mitred abbot of St Alexander is the spiritual chief of the Mirdites. The Orthodox Church has metropolitans at Prizren, Durazzo, Berat, Iannina, and Kortcha; the Bulgarian exarchate maintains a bishop at Dibra. Of the Albanians in Sicily the great majority (44,791) remain faithful to the Greek Church; in Italy 116,482 follow the Latin ritual, and 38,192 the Greek. All the Albanians in Greece belong to the Orthodox Church.

Education.

Education is almost non-existent, and the vast majority of the population, both Christian and Moslem, are totally illiterate. Instruction in the Albanian language is prohibited by the Turkish Government for political reasons; a single exception has been made in the case of an American school for girls at Kortcha. There are Turkish primary and secondary schools in some of the towns; in the village mosques instruction in the Koran is given by the imâms, but neither reading nor writing is taught. The aristocratic Moslem families send their sons to be educated in Constantinople or Vienna. At Scutari a college and a seminary are maintained by the Jesuits, with the aid of the Austrian Government; the Franciscans have several primary schools, and three lay schools are supported by the Italian Government: in all these institutions Italian is the language of instruction. There are two Servian seminaries at Prizren. In Southern Albania there are Greek schools in the towns and a large Greek gymnasium at Iannina. The priests of the Greek Church, on whom the rural population depend for instruction, are often deplorably ignorant. The merchant families of Iannina are well educated; the dialect spoken in that town is the purest specimen of colloquial Greek.

Recent history.

Albania has never had a national history, owing to the want of unity and cohesion amongst its inhabitants; even the heroic resistance of Skanderbeg to the Turks (1443-67) can hardly be described as a great national effort. The surrender of Scutari in 1478 marked the end of Venetian supremacy in Upper Albania; many of the native Christian defenders of the town eventually took refuge in the mountains, and became, it is said, the ancestors of the Catholic Ghegs. Notwithstanding the abandonment of Christianity by a large section of the population, the authority of the sultans was never effectively established, and succeeding centuries present a record of interminable conflicts between the tribesmen and the Turks, between the Christians and the converts to Islam, or between all combined and the traditional Montenegrin enemy. The decline of the Ottoman power, which began towards the end of the 17th century, was marked by increasing anarchy and lawlessness in the outlying portions of the empire. A Moslem chieftain, Mehemet of Bushat, after obtaining the pashalik of Scutari from the Porte, succeeded in establishing an almost independent sovereignty in Upper Albania, which remained hereditary in his family for some generations. In Southern Albania Ali Pasha of Tepelen (*b.* about 1750), an able, cruel, and unscrupulous man, subdued the neighbouring pashas and chiefs, crushed the Suliotes and Khimarrhotes, and exercised a practically independent sovereignty from the Adriatic to the Ægean. He introduced comparative civilization at Iannina, his capital, and maintained direct relations with foreign powers. Eventually he renounced his allegiance to the Sultan, but was overthrown by a Turkish army in 1822. Shortly afterwards the dynasty of Scutari came to an end with the defeat of Mustafa Pasha, the last of the house of Bushat. The opposition of the Albanians, Christian as well as Moslem, to the reforms introduced by the Sultan Mahmûd II. led to the devastation of the country and the expatriation of thousands of its inhabitants. During the next half-century several local revolts occurred, but no movement of a strictly political character took place till after the Berlin Treaty (13th July 1878), when some of the Moslems and Catholics combined to resist the stipulated transference of Albanian territory to Austria-Hungary, Servia, and Montenegro, and the *Albanian League* was formed by an assemblage of chiefs at Prizren. The movement, which was instigated by the Porte with the object of evading the provisions of the treaty, was so far successful that the restoration of Plava and Gusinye to Albania was sanctioned by the Powers, Montenegro receiving in exchange the town and district of Dulcigno. The Albanian leaders, however, soon displayed a spirit of independence, which proved embarrassing to Turkish diplomacy and caused alarm at Constantinople; their forces came into conflict with a Turkish army under Dervish Pasha near Dulcigno (November 1880), and eventually the league was suppressed. A similar agitation on a smaller scale was organized in Southern Albania to resist the territorial concessions awarded by the Powers to Greece. These movements, however, were far from displaying a genuinely national character. In recent years attempts have been made by Albanians resident abroad to propagate the national idea among their compatriots at home; committees have been formed at Brussels, Bucharest, Athens, and elsewhere, and books, pamphlets, and newspapers are surreptitiously sent into the country. Unity of aim and effort, however, seems foreign to the Albanians, except in defence of local or tribal privileges. The growth of a wider patriotic sentiment will depend on the spread of popular education: up to the present no appreciable progress has been made in this direction.

Antiquities.

Albania abounds in ancient remains, which as yet have been little explored. Fragments of Cyclopean structures were discovered by Hahn at Kretzunista, Arinista, and other sites in the district of Argyrokastro; the walls, partly Cyclopean, of an ancient city (perhaps *Bullis*) are visible at Gradista on the Viossa. The remains of the classical epoch attest the influence of Roman rather than of Greek civilization. At Pollina, the ancient *Apollonia*, are the remnants of a Doric temple, of which a single column is still standing. A little north of Preveza are the considerable ruins of Nikopolis, founded by Octavian to commemorate the victory of Actium. At Khimara (ancient *Chimæra*) the remains of an old Greek city may still be seen; at Santa Quaranta (ancient *Onchesmos*) the walls and towers of a later town are in good preservation. Few traces remain of the once celebrated Dyrrhachium. The ruins of Pandosia, Ephyra, Elatea, Phœniké, Buthrotum, Akrolissos, and other towns may be identified. The most important and interesting remains, however, are those of Dodona, near Iannina, the seat of the famous oracle of the Pelasgian Zeus. The ruins, which were excavated by Mr Constantine Carapanos of Athens in 1875, furnished a rich yield of inscriptions, statuettes, vases, and other objects. The temple of Zeus stood in the upper part of a *temenos* or sacred precinct, together with two other buildings, one of which was probably a sanctuary of Aphrodite; the inclosure was approached by propylæa. A remarkably large theatre is situated in a neighbouring valley. For details see Mr Carapanos's work, *Dodone et ses Ruines* (Paris, 1878). Of the mediæval ruins those of Kroïa, the stronghold of Skanderbeg, are the most interesting.

Language.

Albanian is peculiarly interesting as the only surviving representative of the so-called Thraco-Illyrian group of languages which formed the primitive speech of the peninsula. It has afforded an attractive study to philologists, amongst whom may be mentioned Malte-Brun, Leake, Xylander, Hahn, Miklositch, and G. Meyer. The analysis of the language presents great difficulties, as, owing to the absence of literary monuments, no certainty can be arrived at with regard to its earlier forms and later development. The groundwork, so far as it can be ascertained, and the grammar are Indo-European, but a large number of words have been borrowed from the Latin, or Italian, and Greek, and it is not always easy to decide whether the mutilated and curtailed forms now in use represent adopted words or belong to the original vocabulary. There is also a considerable admixture of Turkish and Slavonic words. Notwithstanding certain points of resemblance in structure and phonetics, Albanian is entirely distinct from the neighbouring languages; in its relation to early Latin and Greek it may be regarded as a co-ordinate member of the Aryan stock. It possesses seven vowels; among the consonants are the aspirated *d* and *t*, as in Greek, and many other sounds, such as *b*, *d*, *sh*, *zh* (French *j*), and hard *g*, which are wanting in Greek, but exist in the Slavonic languages. There are three declensions, each with a definite and indefinite form; the genitive, dative, and ablative are usually represented by a single termination: the vocative is formed by a final *o*, as *memmo* from *memme*, "mother." The neuter gender is absent. There are two conjugations; the passive formation, now wanting in most Indo-European languages, has been retained, as in Greek: thus *kerko-iy*, "I seek," forms *kerko-n-em*, "I am sought." The infinitive is not found; as in Greek, Rumanian, and Bulgarian it is replaced by the subjunctive with a particle. The two auxiliary verbs are *kâm*, "I have," and *yâm*, "I am." An interesting and characteristic feature of the language is the definitive article, which is attached to the end of the word: *e.g.*, *mik* ("friend," *amicus*), *mik-u* ("the friend"); *kien* ("dog"), *kein-i*; *Shkumb*, *Shkumb-i*. The suffix-article likewise appears in Rumanian and Bulgarian, but in no other Latin or Slavonic language. Another remarkable analogy between the Albanian and the neighbouring languages is found in the formation of the future; the Albanian *do* (3rd pers. sing. of *dova*, "I will,") like the Greek θὰ, is prefixed without change to all persons of the verb: a similar usage in Servian and Bulgarian, as well as in Rumanian (especially the Macedonian dialect), is peculiar to these languages in the Slavonic and Latin groups. These and other points of similarity have led to the conjecture that the primitive

Illyrian language may have exerted some kind of influence on the other idioms of the peninsula. In the absence of literary culture the Albanian dialects, as might be expected, are widely divergent; the limits of the two principal dialects correspond with the racial boundaries of the Ghegs and Tosks, who understand each other with difficulty: the Albanians in Greece and Italy have also separate dialects. In writing Albanian the Latin character is employed by the Ghegs, the Greek by the Tosks; neither alphabet suffices to represent the manifold sounds of the language, and various supplementary letters or distinguishing signs are necessary. In the use of these no uniform system has yet been adopted. An alphabet of fifty-two letters, some presenting ancient Phœnician and Cretan forms, was found by Hahn in partial use at Elbassan and Tirana; its antiquity, however, has not been established. The Tosks generally use the Greek language for written communications. The native folklore and poetry of the Albanians can hardly compare with that of the neighbouring nations in originality and beauty. The earliest printed works in Albanian are those of the Catholic missionaries; the first book containing specimens of the language was the *Dictionarium Latino-Epiroticum* of Bianchi, printed in 1635. The literature of the last two centuries consists mainly of translations and religious works written by ecclesiastics, some of whom were natives of the Albanian colonies in Italy. The most noteworthy Albanian writer was Girolamo di Rada (*b.* 1815), a poet, philologist, and collector of national folklore. Among his successors may be mentioned Vincenzo Dorsa and Demetrio Camarda.

AUTHORITIES.—HAHN. *Albanesische Studien.* Jena, 1854.—BOPP. *Ueber das Albanesische.* Berlin, 1854.—FALLMERAYER. *Das albanesische Element in Griechenland.* Munich, 1864.—CAMARDA. *Saggio di grammatologia comparata sulla lingua albanese.* Leghorn, 1865. — Viscountess STRANGFORD. *The Eastern Shores of the Adriatic.* London, 1865.—TOZER. *Researches in the Highlands of Turkey.* London, 1869.—MIKLOSICH. *Albanes. Forschungen.* Vienna, 1870.—C. MEYER. "Die Stellung des Albanesischen im Kreise der indogerm. Sprachen," in *Beiträge zur Kunde der indogerm. Sprachen*, vol. viii. Leipzig, 1883.—HECQUARD. *Histoire et description de la Haute Albanie ou Guégarie.* Paris, undated.—GOPCHEVICH. *Oberalbanien und seine Liga.* Leipzig, 1881.—TAJANI. *Le Istoria Albanesi.* Salerno, 1886.—See also MURRAY'S "Greece," ed. 1900, pp. 720-731 and 760-814, and Blue Book "Turkey," No. 15, Part II. 1886.

(J. D. B.)

Albany, a river of Canada, forming part of the boundary between Ontario and Keewatin, rises in Lake St Joseph in (head of lake) long. 91° 25′ W. and lat. 50° 55′ N., and falls into James Bay, its total length being upwards of 500 miles. There are four Hudson's Bay Company's posts on its banks. The Ogoki and Kenogami rivers are the principal tributaries.

Albany, the capital of New York state, and of Albany county, U.S.A., situated in 42° 40′ N. lat. and 73° 45′ W. long. on Hudson river, just below the mouth of Mohawk river. The mean annual temperature is 49°, and the annual rainfall is 40 inches. The death-rate, 20·90 per thousand in 1900, is more than that of the country at large and the average of large cities. The plan of the city presents considerable regularity, although its site, rising sharply from the river in bluffs, is by no means level. The city is divided into nineteen wards, and is supplied with water by pumping from Hudson river and smaller streams, the water-works being owned by the city. The streets are broad, about half of them paved, mainly with granite blocks and cobble stones, and the drainage is fairly good. The fire and police equipment are good. The finest of the many public buildings is the magnificent new state Capitol, situated at the summit of State Street Hill. It is built of granite, enclosing a court, and is 300 by 400 feet on its ground plan. It is not yet entirely completed, but its estimated cost is $25,000,000 dollars. The city contains many educational and scientific institutions. It is entered by four railways—the Boston and Albany, the New York Central and Hudson River, the Delaware and Hudson, and the West Shore. It is also the terminus of the Erie and Champlain canals, and is near the head of navigation on the Hudson river. These various avenues of communication give it a large commerce by rail, canal, and river. Numerous steamboat lines connect it with New York and other river points. It is a manufacturing city of importance, having in 1890 $17,270,000 invested capital, employing 15,041 persons, and its products were valued at $25,531,000. The assessed valuation of property, real and personal, in 1898 was $66,685,000, and the debt of the municipality $3,294,000. The tax-rate, city, county, and state, was $20.60 per thousand dollars. The population in 1880 was 90,758; in 1890 it was 94,923, and in 1900 it was 94,151.

Albany, a city of Georgia, U.S.A., the capital of Dougherty county, situated in the south-western part of the state, on Flint river, at an altitude of 232 feet. It is in the midst of an agricultural region producing cotton and corn, for which this city serves as a supply point. It is a railway centre of importance, being entered by the Plant System, the Georgia and Alabama, the Central of Georgia, and the Albany and Northern railways. The population in 1880 was 3216, in 1890 it was 4008, and in 1900 it was 4606.

Albany, a municipality in West Australia, on King George Sound, 352 miles by rail, and 254 miles by road S.S.E. of Perth, in the county of Plantagenet. It is a port of call for the Peninsular and Oriental Company's and the Orient Company's steamers carrying the Australian mails, and also for those of the Messageries Maritimes and N. G. Lloyd steamers. This town is the health resort of the state. Its harbour is one of the finest on the Australian coast, and is well protected from winds. Defence works have been carried out at King George Sound and Princess Royal Harbour. The climate is very fine, and a scheme for a pure water supply is being devised. The Marine Drive, 5½ miles in circuit, was completed in 1898. Mean temperature (six years) for the year 58·6° F.; for February, 66·1° F.; for July, 52·6° F.; rainfall, 35·55 inches. The population in 1881 was 1024; in 1891, 2665; in 1900 about 3250.

Albany, Leopold George Duncan Albert, DUKE OF, eighth child and youngest son of Queen Victoria, was born 7th April 1853. The delicacy of his health seemed to mark him out for a life of retirement, and as he grew older he evinced much of the love of knowledge, the capacity for study, and the interest in philanthropic and ecclesiastical movements which had characterized his father, the Prince Consort. He matriculated at Christ Church, Oxford, in November 1872, living with his tutor at Wykeham House, St. Giles's, and diligently pursued his favourite studies of science, art, and the modern languages. In 1876, he left the University with the honorary degree of D.C.L., and resided at Boyton

House, Wiltshire, and afterwards at Claremont. On coming of age in 1874, he had been made a Privy Councillor, and granted an annuity of £15,000. He travelled on the Continent, and in 1880 visited the United States and Canada. He was a trustee of the British Museum, a bencher of Lincoln's Inn, and continued to take an active part in the promotion of education and knowledge generally. Like his father and other members of his family, he was an excellent public speaker. On 24th May 1881 he was created Duke of Albany, Earl of Clarence, and Baron Arklow. On 27th April 1882, he married Hélène Frederica Augusta, princess of Waldeck-Pyrmont, and his income was raised by Parliament to £25,000. Having gone to the south of France for his health in the spring of 1884, he was attacked by a fit, the cause or the consequence of a fall in a club-house at Cannes, on 27th March, and died very unexpectedly on the following morning. His death was universally regretted, from the gentleness and graciousness of his character, and the desire and ability he had shown to promote intellectual interests of every kind. He left a daughter, born in February 1883, and a posthumous son, born 19th July 1884, who succeeded to the dukedom of Albany, and who on 30th July 1900 became duke of Saxe-Coburg on the death of his uncle. (R. G.)

Albay, a town of 31,000 inhabitants, on the eastern coast of Luzon, Philippine Islands, and capital of the province of Albay. Well built, with good government and public buildings, it was badly injured by fire in 1900. It is at the centre of one of the most important hemp-producing districts, and ships large quantities of this product to Manila. Other exports are rice, Indian corn, sugar, copra, and cloth made from hemp or from sinamay. It is near the foot of Mayon volcano, and in the year 1714 was completely destroyed during a violent eruption. The language is Bicol.

Albemarle, George Thomas Keppel, SIXTH EARL OF (1799-1891), British general, second son of the fourth earl, was born on 13th June 1799. Educated at Westminster School, he entered the army as ensign, 14th Foot, in 1815. He joined his regiment in Belgium, and took part in the Waterloo campaign and the march to Paris, joined the second battalion in Corfu and was transferred to the 22nd Foot, with which he served in Mauritius and at the Cape, returning home in 1819, when he was appointed equerry to the duke of Sussex. Promoted to a lieutenancy in the 24th Foot, he was transferred to the 20th Foot, and went to India, where he was aide-de-camp to the marquis of Hastings until his resignation in 1823, when Keppel returned to England, travelling overland through Persia, Moscow, and St Petersburg. He published in 1825 an account of his travels, entitled *Journey from India to England*. He was aide-de-camp to the Marquess Wellesley, lord-lieutenant of Ireland, for two years, was promoted captain in the 62nd Foot, studied in the senior department of the Royal Military College at Sandhurst, and in 1827 obtained a half-pay unattached majority. He did not again serve on full pay, but rose to be a general. In 1829 he visited the seat of the Russo-Turkish war and was with the British fleet in Turkish waters. In 1832 he was returned in the Whig interest to the first reformed parliament as member for East Norfolk, and sat until 1835. He was private secretary to the premier, Lord John Russell, in 1846, and M.P. for Lymington from 1847 to 1849. He succeeded to the title on the death of his brother in 1851. He died in 1891, and was buried at Quiddenham, Norfolk. He wrote an account of a *Journey across the Balkans*, *Memoirs of the Marquis of Rockingham*, and an autobiography entitled *Fifty Years of My Life*. (R. H. V.)

Albert, formerly ANCRE, a town of France, arrondissement of Peronne, department of Somme, 16 miles N.E. by E. of Amiens, on railway from Paris to Amiens. The town stands on a branch of the Ancre, which here forms a pretty cascade. There are large and important engineering establishments of every kind. Population (1881), 5374; (1891), 5941; (1896), 6433, (comm.) 6651.

Albert, Frederick Augustus, KING OF SAXONY (1828-1902), was born 23rd April 1828, being the eldest son of Prince Johann, who succeeded to the throne in 1854. His education was, as is usual with German princes, to a great extent military, but he attended lectures at the university of Bonn. His first experience of warfare was in 1849, when he served as a captain in the campaign of Schleswig-Holstein against the Danes. When the war of 1866 broke out, Saxony, which had for many years under the ministry of Beust adopted an anti-Prussian policy, was the most active ally of Austria. The crown prince was given the command over the army; no attempt was made to defend Saxony, but the Saxons fell back into Bohemia and effected a junction with the 1st Austrian army corps under Clam-Gallas. They took a prominent part in the battles by which the Prussians forced the line of the Iser and in the disastrous battle of Gitschin. The crown prince, however, succeeded in effecting the retreat in good order, and in the decisive battle of Königgrätz he held the extreme left of the Austrian position. The Saxons maintained their post with great tenacity, but were driven back after many hours' fighting. During these operations the crown prince won the reputation of a thorough soldier; after peace was made and Saxony had entered the North German Confederation, he was placed in command of the Saxon army, which had now become the 12th army corps of the North German army, and in this position carried out the necessary reorganization. He was a firm adherent of the Prussian alliance. On the outbreak of war in 1870 he again commanded the Saxons, who were included in the 2nd army under Prince Frederick Charles, his old opponent. At the battle of Gravelotte they formed the extreme left of the German army, and with the Prussian guard carried out the attack on St Privat, the final and decisive action in the battle. In the reorganization of the army which accompanied the march towards Paris the crown prince was given a separate command over the 4th or army of the Meuse, consisting of the Saxons, the guards, and the 4th army corps; he was succeeded in his former post by his brother Prince George, who had served under him in Bohemia. He took a leading part in the operations which preceded the battle of Sedan, the 4th army being the pivot on which the whole army wheeled round in pursuit of MacMahon; and the actions of Busancy and Beaumont on 29th and 30th August were fought under his directions; in the battle of Sedan itself, with the troops under his orders, he carried out the circumvention of the French on the east and north. His conduct in these engagements won for him the complete confidence of the army, and during the siege of Paris his troops formed the north-east section of the investing force. After the conclusion of the armistice he was left in command of the German army of occupation, a position which he held till the fall of the Commune. On the conclusion of peace he was made an inspector-general of the army and field-marshal. On the death of his father on 29th October 1873 he succeeded to the throne. His reign was uneventful, and he took little public part in political affairs, but his advice and experience were constantly used in military matters. In 1897 he was appointed arbitrator between the claimants for the principality of Lippe. King Albert married in 1853 Carola, daughter of Prince Gustavus of

Vasa, and grand-daughter of the last king of Sweden of the house of Holstein. He died 19th June 1902. (J. W. He.)

Albert Nyanza AND **Albert Edward Nyanza,** the two western reservoirs of the White Nile, lying north and south in the great Central African rift-valley, near its north end. When the northern lake, Albert Nyanza, was first reached by Sir Samuel Baker, it was thought to extend southwards far beyond the equator—farther, in fact, than the southern end of Albert Edward Lake, which does not reach to 1° S. In 1875 Stanley reached the arm of a lake, situated on the equator, which he thought to be Albert Nyanza, but which the voyages of Gessi and Mason on the latter lake in 1876 and 1877 proved to be distinct.

The true position and form of Albert Edward Nyanza were made known by Stanley's journey of 1888-89, while its contours have since been determined with greater exactness by Stuhlmann (1891) and Grogan and Moore (1899). The lake, which lies at an altitude of about 3200 feet, is roughly elliptical in outline, with a length of 50 miles and maximum breadth of about 30 miles, the area approximating to 1000 square miles. The arm above alluded to is practically an independent lake (Ruisamba) running to the north-east and connected by a narrow channel with the main lake. A swampy plain, traversed by the Ruchuru and other streams, extends to the south of the lake, and must once have been covered by its waters. On the east a wide space intervenes between the eastern wall of the rift-valley and the present shore of the lake, two distinct terraces being clearly defined. The vegetation (Euphorbias, &c.) on the lower of these is of small size and seems to be of recent origin. Near the lake, pits of fire and huge jets of smoke still testify to the presence of volcanic activity. On the west the wall of the rift-valley runs close to the lake, but on the north a barren level plain comes between the lake and the southern spurs of the Ruwenzori range. On this plain, separated by a narrow neck of land from Lake Albert Edward, is a crater-like depression occupied by a shallow salt lake. The salt, which has a reddish tint, is exported to great distances. The main feeder of Lake Albert Edward, the Ruchuru, rises on the north side of the volcanoes north of Lake Kivu (*q.v.*). On reaching the level plain 15 miles from the lake its waters become brackish, and the vegetation on its banks is scanty. The reedy marshes near its mouth form a retreat for a primitive race of fishermen. Lake Ruisamba, the shores of which are generally high, is fed by streams from the east of Mount Ruwenzori. At the north-west corner of the larger lake issues the Isango or Semliki, at first a small stream, but gradually increased to a large river by streams from the Ruwenzori range on the eastern side of the rift-valley. Before entering Albert Nyanza, in 1° 5′ N., it traverses a plain once covered by the latter lake, forming marshes inhabited by another tribe of fishermen, the Wanyabuga. The shores of Lake Albert Edward are partitioned between British East Africa and the Congo Free State, the dividing line being here the 30th meridian of east longitude. Just east of that line the British post of Fort George was established on the north shore by Lugard in 1891.

Lake Albert lies at an altitude of about 2100 feet. Its extreme length is about 100 miles, and its general breadth somewhat over 20, the area being approximately 2000 square miles. It is shut in both on the east and west by plateau escarpments, which for the most part approach the shores closely. Near the south end a plain, saline in places, with a width of some 7 miles, intervenes on the west between the plateau and the lake. At this part there are signs that the lake is shrinking, Nyamsasi, which was an island at the time of Stanley's visit in 1889, having since become a peninsula. Farther north, from Kahoma to Mahagi, the hills descend abruptly to the water, rocky headlands alternating with semicircular beaches. Near the coast the water is in places very shallow, owing to the sediment brought down by mountain torrents, and reeds have been seen growing 2 miles from the shore. The gorges cut in the plateau escarpment produce magnificent timber. This plateau—a sparsely-inhabited rolling upland 2000 to 3000 feet above the lake (the Blue Mountains of Baker)—falls again steeply on the west to the Congo Basin, its maximum width being about 20 miles. The greater part of the shores of Lake Albert fall to British East Africa (Uganda Protectorate), but the stations established at Kibero on the east and Mswa on the west have been abandoned, owing to their unhealthiness. The extreme north-west portion has been leased to the Congo Free State during King Leopold's lifetime, and of this a strip 15 miles wide, reaching the lake at Mahagi, will eventually revert to the state. (E. He.)

Alberta. See North-West Territories.

Albertina. See Orange River Colony.

Albi, chief town of department Tarn, France, 423 miles S. of Paris, on railway from Carmaux to Castelnaudary. The Park of Rochegude, gift of the admiral of that name, contains a fountain adorned with 13th-century carvings. On the Vigan, a fine promenade, is a statue of the navigator La Pérouse, who was born here. Manufactures of umbrellas and hats, the latter forming a considerable branch of industry, have become important. Population (1881), 14,729; (1891), 14,219; (1896), 14,983, (comm.) 18,750.

Albina, formerly a city of Multnomah county, Oregon, U.S.A., annexed to Portland in 1891. It is on the east bank of the Willamette river, not far from its mouth, in the north-western part of the state. The population in 1880 was 123; in 1890 it was 5129; in 1900 (see Portland).

Albox, a town of Spain, in the province of Almeria, 42 miles N.N.E of Almeria. It owes its prosperity to woollen, spart, and flour industries, and to the wine, olive oil, and spart produced in the surrounding fertile country, where also live stock is abundant, especially sheep, goats, and mules. Population (1897), 10,313. Albox was originally an Arab town, Box. An earthquake almost entirely destroyed it in 1563, and it had to be rebuilt in great part.

Albrecht, Frederick Rudolph, Archduke of Austria (1817-1895), eldest son of the Archduke Charles who defeated Napoleon at Aspern, was born on 3rd August 1817 at Vienna. He began his military career at the age of twenty, and after holding several minor posts, was in 1844 appointed commander of the forces in Upper and Lower Austria. It was his duty therefore to maintain order during the disturbances of 1848, and at the outbreak of revolution in Vienna during the month of March he was in command of the troops who came into collision with the rioters. Owing to the collapse of the Government it was impossible to repress the disturbances, and he was relieved from a post which brought much unpopularity and was not suitable to be held by a member of the imperial family. Like so many others of the Austrian military he spent the summer of 1848 in the army of Italy, under Radetzky, and though he was given no command he fought with distinction as a volunteer in the battles of Santa Lucia and Pastrengo. In the campaign of 1849 he was placed in command of the second division, which was in the vanguard of the army, and he gained

great credit for the resolution with which, at the battle of Novara, he held his ground against the superior forces of the enemy. From 1851 to 1860 he commanded the forces in Hungary, a post of great political difficulty. In 1859 and 1864 he was sent on important military and diplomatic missions to Berlin. When war became imminent in 1866 the archduke, who had now been made field-marshal, was placed in command of the Austrian army in Italy. With an army of about 130,000 he had to keep in check the Italian forces of nearly double the number. In the short campaign which followed he displayed the highest military qualities; leaving only a small force to watch the army which was advancing from the Po, with 75,000 men he attacked 130,000 Italians, who under the command of the king had crossed the Mincio, and at the battle of Custozza (23rd June) defeated them with the loss of 8000 men and fourteen cannon. The result of this battle was that both the Italian armies had to retreat, and the archduke was able to send 50,000 men to reinforce the northern army, when, after being defeated by the Prussians, it fell back on Vienna. The Italians, moreover, had to give up the hope of obtaining from Austria any territory except Venetia. On 10th July the archduke was summoned to Vienna to take command of the combined forces which were being collected to defend the capital, but peace was made before further hostilities took place. From this time he was chiefly occupied with the reform and reorganization of the Austrian army; he was made inspector-general of the forces in 1868. In 1870 he conducted the military negotiations preparatory to an alliance with France, which, however, was not concluded. He married, in 1844, Hildegarde, daughter of Ludwig, first king of Bavaria, who died in 1864. He died himself 18th February 1895, leaving two daughters. His only son died in childhood, and his nephew, Archduke Frederick (born 1856), inherited his great possessions.
(J. W. HE.)

Albuquerque, a city of New Mexico, U.S.A., the capital of Bernalillo county, situated in the central part of the territory, on the east bank of the Rio Grande, in 35° 05′ N. lat. and 106° 38′ W. long., at an altitude of 4950 feet. The streets extend in a regular plan over a plain sloping gently to the river. It is the connecting point of two main lines of the Atchison, Topeka, and Santa Fe railway system. The old Mexican town of Albuquerque, which antedates American jurisdiction over the region, lies about two miles north-west of the modern town, with which it is connected by a street railway. The population of the new town in 1890 was 3785, and in 1900 it was 6238; of the old Mexican town, 1733 in 1890, and 1191 in 1900.

Albury, a town in Australia, New South Wales, in the county of Goulburn; it stands on the border of Victoria and on the right bank of the Murray river, here spanned by two bridges, one carrying the roadway, the other the double railway; 386 miles by rail from Sydney. The Murray is navigable for small steamers from this town to its month, a distance of 1800 miles. Altitude 572 feet. Mean rainfall (23 years) 26·39 inches. Population (1881), 5715; (1891), 5447; (1901), 5820.

Alcala de Henares, a city of Spain, 17 miles E.N.E. of Madrid. Population, 8745. After the transfer of the university to Madrid the Government turned most of the principal buildings erected by Cardinal Cisneros in the 16th century into a depôt for the archives of various state departments. Here, too, are kept very complete and curious documents of the Inquisition, showing all its workings from the 15th to the 19th century.

Alcala de Los Gazules, a town of Spain, province of Cadiz, 32 miles E. by S. of Cadiz. It has a splendid climate, and the soil in the surrounding districts is very fertile. There is a prosperous cork industry. It was originally a Moorish town, as its name indicates. Population (1897), 10,027.

Alcamo, a town of Sicily, Italy, in the province of Trapani, 24 miles S.W. from Palermo. It stands 837 feet above sea-level, and produces wine. It was originally a Saracenic town, and was made Christian by the Emperor Frederick II. in 1233. Population (1881), 37,697; (1901), 51,811.

Alcester, a market-town and railway station, under a rural district council, in the south-western parliamentary division of Warwickshire, England, on the Alne, 15 miles W.S.W. of Warwick. A Roman Catholic school chapel, a hospital for infectious diseases, and a reading room have been erected. The manufacture of needles has declined; in the town there are implement works, cycle works, and a brewery. Area, 1626 acres. Population of rural district (1901), 11,392.

Alcester, Frederick Beauchamp Paget Seymour, Baron (1821-1895), British admiral, son of Colonel Sir Horace Beauchamp Seymour, and cousin of Francis George Hugh Seymour, 5th Marquis of Hertford, was born on 12th April 1821. Entering the navy in 1834, he served in the Mediterranean and the Pacific, was for three years flag-lieutenant to his uncle Sir George Seymour, and was promoted to be commander in 1847. He served in Burma as a volunteer in 1852; was made a captain in 1854; took the *Meteor* ironclad battery out to the Black Sea and home again in 1856; was captain of the *Pelorus* on the Australian station from 1857 to 1863, and commanded the naval brigade in New Zealand during the Maori war, 1860-61, for which he was made a C.B. He became a rear-admiral in 1870; in 1871-72 he commanded the flying squadron; was a lord of the Admiralty in 1872-74, and commanded the Channel fleet, 1874-76. On 31st December 1876 he was made a vice-admiral; a K.C.B. on 2nd June 1877. In 1880-83 he was commander-in-chief of the fleet in the Mediterranean, and in 1880 had also the chief command of the European squadron sent to the coast of Albania as a demonstration to compel the Porte to cede Dulcigno to Montenegro. On 24th May 1881 he was made a G.C.B., and on 6th May 1882 was promoted to the rank of admiral. In July 1882 he commanded at the bombardment of Alexandria and in the subsequent operations on the coast of Egypt, for which service he was raised to the peerage as Baron Alcester of Alcester in the county of Warwick, received a parliamentary grant of £25,000, the freedom of the city of London, and a sword of honour. On his return from the Mediterranean he was for a couple of years again at the Admiralty, and in 1886 he was placed on the retired list. For the next nine years he lived chiefly in London, but latterly his health was much broken, and he died on 30th March 1895. He was unmarried, and the peerage became extinct.
(J. K. L.)

Alcock, Sir Rutherford (1809-1897), British consul and diplomatist, was the son of Dr Thomas Alcock, who practised at Ealing, near London, and himself followed the medical profession. In 1836 he became a surgeon in the marine brigade which took part in the Carlist war, and gaining distinction by his services was made deputy inspector-general of hospitals. He retired from this service in 1837, and seven years later was appointed consul at Foochow in China, where, after a short official stay at Amoy, he performed the functions, as he himself expressed it, "of everything from a lord chancellor to a sheriff's officer." Foochow was one of the forts opened to trade by the treaty of 1842, and Mr Alcock, as he then was, had to maintain an entirely new position with the Chinese authorities. In so doing he was eminently successful, and earned for himself promotion to the consulate at Shanghai. Thither he went in 1846, and made it an especial part of his duties to superintend the establishment and laying out of the British settlement, which has developed into such an important feature of British commercial life in China. In 1858 he was appointed consul-general in the newly-opened empire of Japan, and in the following year was promoted to be minister plenipotentiary. In those days residence in Japan was surrounded with many dangers, and the people were intensely hostile to foreigners. In 1860 Mr Alcock's native interpreter was murdered at the gate of the Legation, and in the following year the Legation was stormed by a body of Ronins, whose attack was repulsed by Mr Alcock and his staff. Shortly after this event he returned to England on leave. Already he had been made a C.B. (1860), and in 1862 he was made a knight commander of the order. Two years later he returned to Japan, and after a year's further residence he was transferred to Peking, where he represented the British Government until 1871, when he retired. But though no longer in official life his leisure was fully occupied. He was for some years president of the Royal Geographical Society, and he served on many commissions. He was twice married, first in May 1841 to Henrietta Mary, daughter of Charles Bacon, Esq., who died in 1853, and secondly (8th July 1862) to the widow of the Rev. John Lowder, who died on 13th March 1899. He was the author of several works, but the one by which he will be known is *The Capital of the Tycoon*, which appeared in 1863. He died in London on 2nd November 1897. (R. K. D.)

Alcott, Amos Bronson (1799-1888), American educationalist and writer, was born in Wolcott, Connecticut, 29th November 1799. His father was a farmer and mechanic, Joseph Chatfield Alcox, whose ancestors, then bearing the name of Alcocke, had settled in eastern Massachusetts in early colonial days. The external events in Amos Bronson Alcott's long life were, for the most part, simple and unimportant. Self-educated in youth, and early thrown upon his own resources, he began to earn his living by peddling books and merchandise in Virginia, afterward teaching in that state and in other southern states. Determined to devote himself to educational work, in 1828 he opened, in Boston, a school which became locally famous because of his original methods; his plan being to develop self-instruction on the basis of self-analysis, with an ever-present desire on his own part to stimulate the child's personality. The feature of his school which attracted most attention, perhaps, was his scheme for the teacher receiving punishment, in certain circumstances, at the hands of an offending pupil, whereby the sense of shame might be quickened in the mind of the errant child. The school was not pecuniarily successful, although Alcott had won the affection of some of his pupils, and his educational experiments had challenged the attention of students of pedagogy. After a visit to England, in 1842, he founded, with two English associates, at "Fruitlands," in the town of Harvard, Massachusetts, a communistic experiment at farm-living and nature-meditation, as tending to develop the best powers of body and soul. This speedily came to naught, and Alcott subsequently took up his home near Emerson, in Concord, Massachusetts, and spoke, as opportunity offered, before the "lyceums" then common in various parts of the United States, or addressed groups of hearers as they invited him. These "conversations," as he called them, were more or less informal talks on a great range of topics, spiritual, æsthetic, and practical, in which he emphasized the ideas of the school of American Transcendentalists led by Emerson, who was always his supporter and discreet admirer. He dwelt upon the illumination of the mind and soul by direct communion with the Creative Spirit; upon the spiritual and poetic monitions of external nature; and upon the benefit to man of a serene mood and a simple way of life. As regards the trend and results of Alcott's philosophic teaching, it must be said that, like Emerson, he was sometimes inconsistent, hazy, or abrupt. But though he formulated no system of philosophy, and seemed to show the influence now of Plato, now of Kant, or of German thought as filtered through the brain of Coleridge, he was, like his American master, associate, and friend, steadily optimistic, idealistic, individualistic. The teachings of William Ellery Channing, a little before, as to the sacred inviolability of the human conscience — anticipating the later conclusions of Martineau—really lay at the basis of the work of most of the Concord Transcendentalists and contributors to *The Dial*, of whom Alcott was one. In his last years, living in a serene and beautiful old age in his Concord home, where every comfort was provided by his daughter Louisa (*q.v.*), Alcott was gratified at being able to become the nominal, and at times the actual, head of a Concord summer school of philosophy, in which—in a rudely-fashioned building next his house—thoughtful listeners were addressed, during a part of several successive summer seasons, on many themes in philosophy, religion, and letters. Of Alcott's published works the most important is *Tablets* (1868); next in order of merit is *Concord Days* (1872). His *Sonnets and Canzonets*, 1882, are chiefly interesting as an old man's experiments in verse. He left a great and symmetrical collection of personal jottings and memorabilia, most of which remain unpublished. He died in Boston, 4th March 1888. (C. F. R.)

Alcott, Louisa May (1832-1888), during the last quarter of the 19th century the favourite American author of juvenile stories (especially for girls), was the daughter of Amos Bronson Alcott, and though of New England parentage and residence, was born in Germantown, Pennsylvania, 29th November 1832. She began work at an early age as teacher and writer, and was an amateur nurse in army hospitals during the civil war of 1861-65. Her newspaper letters, collected as *Hospital Sketches* (1863), displayed some power of observation and record; while *Moods*, a novel (1864), despite its uncertainty of method and of touch, indicated the possibility that Miss Alcott might develop into a strong novelist of character, with a sympathetic insight into the deeper springs of vital action. She soon turned, however, to the rapid production of stories for girls, and, with the exception of the cheery tale entitled *Work* (1873), and the anonymous novelette *A Modern Mephistopheles* (1877), which attracted little notice, she did not return to the more ambitious fields of the novelist. Her success dated from the appearance of the first series of *Little Women: or, Meg, Jo, Beth, and Amy* (1868), in which, with unfailing humour, freshness, and lifelikeness, she put into story form many of the sayings and doings of herself and her sisters. *Little Men* (1871) similarly treated the character and ways of her nephews, in that house in Concord, Massachusetts, in which Miss Alcott's industry had now established her parents and other members of the Alcott family; but most of her later volumes, *An Old Fashioned Girl*, *Aunt Jo's Scrap Bag* (6 volumes), *Rose in Bloom*, &c., followed in the line of *Little Women*, of which the author's large and loyal public never wearied. Her natural love of labour, her wide-reaching generosity, her quick perception, and her fondness for sharing with her many readers that cheery humour which radiated from her personality and her books, led her to produce stories of a diminishing value, and at length she succumbed to overwork, dying in Boston 6th March 1888, two days after the death of her father in the same city. Miss Alcott's early education had partly been given by the naturalist Thoreau, but had chiefly been in the hands of her father; and in her girlhood and early womanhood she had fully shared the trials and poverty incident to the life of a peripatetic idealist. In a newspaper sketch entitled "Transcendental Wild Oats," afterwards reprinted in the volume *Silver Pitchers*, she narrated, with a delicate humour, which shows what her literary powers might have been if freed from drudgery, the experiences of her family during an experiment towards communistic "plain living and high thinking" in the town of Harvard, Massachusetts, in 1843. The story of her career has been fully and frankly told in Mrs Ednah D. Cheney's *Louisa May Alcott: her Life, Letters, and Journals* (1889), one of the most noteworthy of American biographies, considered as an unconsciously pathetic record of a cheery woman's life-sacrifice for the support and comfort of her relatives. (C. F. R.)

Alcoy, a town of the province of Alicante, Spain. It has much grown in importance owing to its manufactures, in which that of linen must be included. New private and public schools, a chamber of commerce, town hall, barracks, hospital, institute, and casinos have been built and the churches repaired. It has been frequently the scene of strikes and popular disturbances. Population (1897), 30,118.

Alcyonaria. See ANTHOZOA.

Aldan, a river of Asiatic Russia, East Siberia, a right bank tributary of the Lena, rises in the southern parts of the high plateau of East Siberia, flows mostly over desert highlands for 1160 miles N.E., N., and N.W., and joins the Lena 120 miles below Yakutsk. There are a few settlements in its lower course. The *Aldan Range* is the name given to the part of the Stanovoi border range which faces the Sea of Okhotsk.

Aldeburgh, or ALDBOROUGH, a municipal borough (1885), market-town, and railway station in the Woodbridge parliamentary division of Suffolk, England, on the coast, 24 miles E.N.E. of Ipswich. A small 16th-century moot-hall, restored in 1855, is used for corporation meetings. The church of St Peter and St Paul was restored in 1882 and 1891. A jubilee hall has been erected. There is an excellent golf course. Area, 1972 acres. Population (1881), 2106; (1891), 2159; (1901), 2405.

Aldershot, a town and parish of England, 35 miles S.W. of London by rail, in the Basingstoke parliamentary division of Hampshire, situated one mile from the Basingstoke Canal. A mere village till 1855, when Aldershot Camp was established, the town was in 1857 erected into a local government district, and in 1894 was created an urban district. The ancient parish church was restored in 1891. There are a theatre and a cottage hospital (1897). Area of urban district, 4178 acres. Population (1881), 20,155; (1891), 25,595; (1901), 30,974.

Military Depot.—"Camp" is no longer a suitable name for the military buildings at Aldershot. The wooden huts erected in 1855, which formed the North and South Camps, were not calculated to last many years, and it became necessary to replace them with permanent buildings. A commencement was made in 1881, and under the Barracks Act, 1890, and the Military Works Acts of 1897 and 1899, large sums were provided for completing the work. Although a few wooden buildings remain for a time, the expenditure of nearly £1,800,000 thus provided has made Aldershot, at the commencement of the 20th century, by far the largest assemblage of permanent barracks, as well as the greatest training station for troops, in the British Empire.

The Old North Camp is now named Marlborough Lines, with a three-battery field artillery barrack and five infantry battalion barracks called after Marlborough's victories—Blenheim, Malplaquet, Oudenarde, Ramillies, and Tournay. South Camp is now named Stanhope Lines, after Mr. Stanhope, secretary of state for war when the Barracks Act, 1890, was passed and the reconstruction commenced in earnest. They contain barracks for the Royal Engineers and Army Service Corps north of the General Parade, which stretches east and west, and four infantry battalion barracks south of it, with a fifth at the east, called Albuera, Barossa, Corunna, Maida (Sicily), and Mandora (Egypt), after battles of the wars with France, 1793-1815, in which Wellington did not command. There are also barracks for the Royal Army Medical Corps. The old permanent barracks have been renamed Wellington Lines, with barracks for three cavalry regiments, west, east, and south; for three batteries of horse and three batteries of field artillery; and for three infantry battalions called Badajos, Salamanca, and Talavera, after Wellington's victories in the Peninsula. For the sick there are the Connaught Hospital in Marlborough Lines, the Cambridge Hospital in Stanhope Lines, and the Union Hospital in Wellington Lines, besides the Louise Margaret Hospital for women and children alongside Cambridge Hospital, and the infection hospital on the isolated Thornhill, half for men and half for women and children. The buildings in Wellington Lines, for the most part completed about 1857, are in some respects not up to the modern standard, but those in Stanhope and Marlborough Lines may be regarded as typical examples of modern barracks and hospitals.

The drainage of the station is all modern and of the best description, and the sewage is disposed of on a sewage farm worked by an expert, under the direction of the War Department, with the primary object of meeting all sanitary requirements, not of making a profit. The water-supply is partly from the Aldershot Water Company, and partly from springs and reservoirs collecting water from a reserved area of War Department property. The lighting of Wellington Lines is by gas, and Stanhope and Marlborough Lines are lighted by electricity.

Most of the barracks are large enough to accommodate not only the units they are constructed for, but also detachments of soldiers from other stations who are going through courses of instruction. Including these detachments and the large number of soldiers' wives and children for whom quarters are provided, the population of the station may at times reach a total of 24,000, with 4000 or more horses.

Besides the regimental buildings there are a large number of buildings for garrison purposes, in addition to the hospitals already mentioned; such as quarters and offices for general, staff, and departmental officers, with the warrant and non-commissioned officers employed under them; the supply depot with abattoir and bakery, whence the garrison is supplied with rations both of food and forage; the ordnance stores, where are kept all kinds of military stores and mobilization equipment, barrack stores for furniture and bedding, engineer shops and stores for services performed by the Royal Engineers, the balloon establishment for the manufacture of military balloons, the vaccine establishment for the production of calf-lymph for the army, the military prison, fire brigade stations, five churches, recreation grounds for officers and men, schools for the literary instruction of adults and children, and especially those military technical schools which form one of the chief features of Aldershot as a training station. These technical schools are as follows: army cookery school, for training cooks who shall not only cook for soldiers, but also teach them to cook for themselves; army gymnastic school, for the gymnastic instruction of the troops at Aldershot, and especially for training instructors for other stations; Army Service Corps school, for instruction of Army Service Corps officers in their duties; army signalling school, for training signallers; army veterinary school, for training of officers and men, the latter as farriers; ballooning school, for instruction and training of officers and men in the management of balloons; mounted infantry school, for instruction of officers and men in the duties of mounted infantry, the whole training of which force is carried out at Aldershot; training school for Royal Army Medical Corps, for training officers and men for their duties in hospital and field.

The work of these schools is, however, only a small part of the military training afforded at Aldershot: there still remain those very important branches for which Aldershot was originally started, and for the carrying out of which a considerable extent of land is essential, viz., musketry, company training, reconnaissance, and field days. For these purposes a large tract of land was purchased between 1854 and 1860, and since then additional property has been acquired from time to time, so that at present it extends, though with many interruptions, over an area about 9½ miles in extreme length by 7¼ miles in extreme width. In addition to this there is the land at Sandhurst and the Staff College, about 6½ miles distant, and at Wolmer Forest, 12 miles distant. The musketry practice of the troops at Aldershot is carried out at the Ash ranges, 2 miles east of the barracks, while the Pirbright ranges, alongside those of the National Rifle Association at Bisley, are utilized by the household cavalry and guards, who are encamped there in succession. Suitable land, within an easy march of the barracks, is utilized for company, battalion, and brigade training of infantry, while the mounted branches work over a wider area, and the engineers carry out their practices where most convenient. For field days of the three arms—cavalry, artillery, and infantry—the whole of the War Department property is available.

Besides the troops in barracks, during the drill season there is often a considerable force in camp, both regular troops from other stations, and militia and volunteers. Some sixty camping grounds have been specially prepared for them, so that, including the regular garrison, sometimes as many as 40,000 troops have been concentrated at the station for training and manœuvres.

(H. Lo.)

Aldrich, Thomas Bailey (1836-——), American author, was born in Portsmouth, New Hampshire, on the 11th November 1836; his birthplace being the "Rivermouth" of several of his longer and shorter stories, while the Piscataqua river, the Isles of Shoals, and other scenes familiar to his boyhood, are frequently commemorated in his prose and verse. His early life—partly described in his *Story of a Bad Boy* (1869), in which "Tom Bailey" is the juvenile hero—was spent in business offices in New Orleans and New York, until his literary tastes led him to become a contributor to various newspapers in the latter city. Between 1856 and 1859 he was on the staff of the New York *Home Journal*, then edited by the once popular poet N. P. Willis; while during a part of the civil war he was editor-in-chief of the *New York Illustrated News*, the most graphic of the pictorial recorders of that conflict. These journalistic experiences brought him into close relations with Stedman, Stoddard, Taylor, Whitman, the sculptor Launt Thompson, and many others of the younger writers and artists of the "sixties," some of whom essayed to set up a mild Bohemia in the American metropolis. In later years he edited the eclectic (and, for a time, illustrated) weekly *Every Saturday*, Boston, between 1870 and 1874, and *The Atlantic Monthly* for nine years, beginning with 1881. Aldrich's successive books of verse, chiefly *The Ballad of Babie Bell* (1856), *Pampinea, and Other Poems* (1861), *Flower and Thorn* (1876), *Friar Jerome's Beautiful Book* (1881), *Thirty-six Lyrics and Twelve Sonnets* (1881), *Mercedes and Later Lyrics* (1883), *Wyndham Towers* (1889), and the collected editions of 1865 and 1882, showed him to be a poet of lyrical skill, dainty touch, and felicitous conceit, the influence of Herrick being constantly apparent. He has repeatedly essayed the long narrative or dramatic poem, but seldom with success, save in such earlier work as *Garnaut Hall* in the 1865 collection. But no American poet has shown more skill in describing some single picture, mood, conceit, or episode. The best things he has written are such lyrics as "Hesperides," "When the Sultan goes to Ispahan," "Before the Rain," "Nameless Pain," "The Tragedy," "Seadrift," "Tiger-Lilies," "The One White Rose," "Palabras Cariñosas," "Destiny," or the eight-line poem "Identity," which did more to spread Aldrich's reputation than any of his writing after the "Babie Bell" of 1856. Beginning with the collection of stories entitled *Marjorie Daw and Other People* (1873), Aldrich applied to his later prose work that minute care in composition which had previously characterized his verse—taking a neat, new, or salient situation, and setting it before the reader in a pretty combination of kindly realism and reticent humour. In the novels of *Prudence Palfrey* (1874), *The Queen of Sheba* (1877), and *The Stillwater Tragedy* (1880), there is more rapid action; but the Portsmouth pictures in the first-named are elaborated with the affectionate touch shown in the shorter humorous tale, *A Rivermouth Romance*. In *An Old Town by the Sea* (1893), the author's birthplace was once more commemorated in plainer colours, while travel and description are the theme of the chapters entitled *From Ponkapog to Pesth* (1883), though the portrayals are still those of a poet and humorist.

Aleardi, Aleardo, Count (1812-1878), Italian poet, was born at Verona, 4th November 1812, and thus soon after his birth became an Austrian subject. Inspired from his cradle with a hatred of the foreigner, he found himself disqualified for the position in the public service to which his rank would have entitled him, and unable to publish his patriotic verses. *Arnaldo da Rocca*, a narrative poem, nevertheless appeared in 1842, and the revolutionary year 1848 made an opening for his *Lettere a Maria*. He took an active part in the popular uprising, and was for some time imprisoned. In 1856 he produced the finest of his pieces, an ode to the maritime cities of Italy, and in 1858 a poem on his own misfortunes. After the expulsion of the Austrians from Lombardy he returned to Verona, published his poems in a collected edition, became professor at the Academy of Fine Art, member of the Italian Parliament, and eventually senator. He died on 17th July 1878. Aleardi's warmth of patriotic feeling hardly finds adequate expression in his poetry; it is his merit to excel in description, but his fault to substitute description for action.

Alefi. See New Caledonia.

Alemtejo, a southern province of Portugal, measuring 155 miles long from N. to S., and 60 miles in mean breadth, with an area of 9425 square miles, and population 393,054; density, 41·7 inhabitants to the square mile. The horses in this province embrace the Alter breed, the finest in the kingdom. Marble is found, and there are copper and iron mines. Mineral waters exist at Aljustrel, Cabeço de Vide, Mertola, Ouguella, Portalegre, Souzel, and Vimieiro. Cloth is manufactured at Portalegre and pottery at Estremoz. The only port is Villa Nova de Milfontes. There are meteorological stations at Evora, Beja, and Campo Maior.

Aleppo, (1) a viláyet of Asiatic Turkey, in Northern Syria. The mountain districts, which occupy nearly half the area, are rich in mineral wealth, and the large inland plains are fertile but uncultivated. Mineral springs are numerous. Nearly all the external trade passes through Alexandretta; the average annual value of the exports for 1896-98 was £1,075,453, and of imports £2,014,012. Population, 995,800 (Moslems and Ansarieh, 792,400; Christians, 183,400; Jews, 20,000). (2) The chief town of the viláyet, situated near the edge of the Syrian desert, in a fertile valley, almost enclosed by limestone hills, through which runs the Koweik (*Chalus*). Its former importance and rapid recovery from repeated disaster were due to its position on the caravan route to Baghdad, Persia, and India. Its large trade led to the establishment of a British consulate and factory in the reign of Elizabeth. The opening of the sea route to India affected its prosperity, but it is still the emporium of Northern Syria, and connected with its port Alexandretta by a carriage road (96 miles). Aleppo was a place of importance 2000 years B.C., and is mentioned in Egyptian and Assyrian inscriptions. It was enlarged and called *Berœa* by Seleucus Nicator, but the old name afterwards reasserted itself under the form *Haleb.* It was rebuilt after an earthquake in the 12th century by the famous Núr ed-Dín, and was closely connected with the history of Saladin and his successors. The town has always retained its Arab character, and the Christians and Jews have their own quarters. Population, 129,000 (Moslems, 98,000; Christians, 23,000; Jews, 8,000). It is the seat of a British consulate.

Alessandria, chief town of the Italian province of the same name, situated almost entirely upon the right bank of the river Tanaro, slightly to the west of its confluence with the Bormida. It is distant 57 miles from Turin by rail. The population numbers 70,000, half living in the city proper and half in the suburbs. Alessandria is therefore divided into two municipal districts, the one within, the other outside the walls. It is the headquarters of the second army corps. From a military point of view its importance is great, its citadel being considered one of the principal bulwarks of Italy and the strategic key of Piedmont. The interior of the cathedral was recently restored in Bramantesque style, according to designs by Count Mella. Among public buildings are the provincial and municipal palaces, the civil hospital, lately remodelled in accordance with modern hygienic exigencies, the synagogue, the lunatic asylum, the episcopal seminary, the library, and the municipal theatre. The cattle market with its vast roofing and pens is the most important in Italy. Education is provided for by a royal lyceum-gymnasium, by a technical school and an institute, and by a normal female school. In regard to charitable institutions Alessandria is provided with a foundling hospital, a refuge for mendicants, and several asylums and hospitals. More than 50 mutual benefit associations provide for the insurance of the working classes, while an important savings bank testifies to the thrift of the population. The principal monuments are statues to the liberal statesman Urbano Rattazzi, to Andrea Vochieri, and to the Alessandrians who fell during the Risorgimento. The chief manufactures are furniture-making, hat-making, and iron-smelting. Trade is favoured by the circumstance that the town stands at the converging point of several valleys, rich both in industrial and agricultural products. (A. FR.)

Aleutian Islands. See ALASKA.

Alexander II. (1818-1881), emperor of Russia, eldest son of Nicholas I., was born on 29th April 1818. His early life gave little indication of his subsequent activity, and up to the moment of his accession in 1855 no one ever imagined that he would be known to posterity as a great reformer. In so far as he had any decided political convictions, he seemed to be animated with that reactionary spirit which was predominant in Europe at the time of his birth, and continued in Russia to the end of his father's reign. In the period of thirty years during which he was heir-apparent, the moral atmosphere of St Petersburg was very unfavourable to the development of any originality of thought or character. It was a time of government on martinet principles, under which all freedom of thought and all private initiative were as far as possible suppressed vigorously by the administration. Political topics were studiously avoided in general conversation, and books or newspapers in which the most keen-scented press-censor could detect the least odour of political or religious free-thinking were strictly prohibited. Criticism of existing authorities was regarded as a serious offence. The common policeman, the insignificant scribe in a public office, and even the actors in the "imperial" theatres, were protected against public censure as effectually as the Government itself; for the whole administration was considered as one and indivisible, and an attack on the humblest representative of the imperial authority was looked on as an indirect attack on the fountain from which that authority flowed. Such was the moral atmosphere in which young Alexander Nicolaevitch grew up to manhood. He received the education commonly given to young Russians of good family at that time—a smattering of a great many subjects, and a good practical acquaintance with the chief modern European languages. Like so many of his countrymen he displayed great linguistic ability, and his quick ear caught up even peculiarities of dialect. His ordinary life was that of an officer of the Guards, modified by the ceremonial duties incumbent on him as heir to the throne. Nominally he held the post of director of the military schools, but he took little personal interest in military affairs. To the disappointment of his father, in whom the military instinct was ever predominant, he showed no love of soldiering, and gave evidence of a kindliness of disposition and a tender-heartedness which were considered out of place in one destined to become a military autocrat. These tendencies had been fostered by his tutor Zhukovski, the amiable, humanitarian poet, who had made the Russian public acquainted with the literature of the German romantic school, and they remained with him all through life, though they did not prevent him from being severe in his official position when he believed severity to be necessary. In 1841 he married the daughter of the Grand Duke Ludwig II. of Hesse, Maximilienne Wilhelmine Marie, thenceforward known as Maria Alexandrovna, who bore him six sons and two daughters. He did not travel much abroad, for his father, in his desire to exclude from Holy Russia the subversive ideas current in Western Europe, disapproved foreign tours, and could not consistently encourage in his own family what he tried to prevent among the rest of his subjects. In the years, however, immediately preceding his accession, he was entrusted with several missions to the courts of Berlin and Vienna. On 2nd March 1855, during the Crimean war, he succeeded to the throne on the death of his father.

ALEXANDER II.
(From a photograph by W. & D. Downey, London.)

The first year of the new reign was devoted to the prosecution of the war, and, after the fall of Sebastopol, to negotiations for peace. Then began a period of radical reforms, recommended by public opinion and carried out by the autocratic power. The rule of Nicholas, which had sacrificed all other interests to that of making Russia an irresistibly strong military power, had been tried by the Crimean war and found wanting. A new system must, therefore, be adopted. All who had any pretensions to enlightenment declared loudly that the country had been exhausted and humiliated by the war, and that the only way of restoring it to its proper position in Europe was to develop its natural resources and to reform thoroughly all branches of the administration. The Government found, therefore, in the educated classes a new-born public spirit, anxious to assist it in any work of reform that it might think fit to undertake. Fortunately for Russia the autocratic power was now in the hands of a man who was impressionable enough to be deeply influenced by the spirit of the time, and who had sufficient prudence and practical common-sense to prevent his being carried away by the prevailing excitement into the dangerous region of Utopian dreaming. Unlike some of his predecessors, he had no grand, original schemes of his own to impose by force on unwilling subjects, and no pet crotchets to lead his judgment astray; and he instinctively looked with a suspicious, critical eye on the panaceas which more imaginative and less cautious people recommended. These traits of character, together with the peculiar circumstances in which he was placed, determined the part which he was to play. He moderated, guided, and in great measure realized the reform aspirations of the educated classes. Though he carefully guarded his autocratic rights and privileges, and obstinately resisted all efforts to push him farther than he felt inclined to go, he acted for several years somewhat like a constitutional sovereign of the Continental type. At first he moved so slowly that many of the impatient, would-be reformers began to murmur at the unnecessary delay. In reality not much time was lost. Soon after the conclusion of peace important changes were made in the legislation concerning industry and commerce, and the new freedom thus accorded produced a large number of limited liability companies. At the same time plans were formed for constructing a great network of railways, partly for the purpose of developing the natural resources of the country, and partly for the purpose of increasing its powers of defence and attack.

Emancipation of the serfs.

Then it was found that further progress was blocked by a great obstacle, the existence of serfage; and Alexander II. showed that, unlike his father, he meant to grapple boldly with the difficult and dangerous problem. Taking advantage of a petition presented by the Polish landed proprietors of the Lithuanian provinces, praying that their relations with the serfs might be regulated in a more satisfactory way—meaning in a way more satisfactory for the proprietors—he authorized the formation of committees "for ameliorating the condition of the peasants," and laid down the principles on which the amelioration was to be effected. This was a decided step, and it was followed by one still more significant. Without consulting his ordinary advisers, his Majesty ordered the minister of the interior to send a circular to the provincial governors of European Russia, containing a copy of the instructions forwarded to the governor-general of Lithuania, praising the supposed generous, patriotic intentions of the Lithuanian landed proprietors, and suggesting that perhaps the landed proprietors of other provinces might express a similar desire. The hint was taken, of course, and in all provinces where serfage existed emancipation committees were formed. The deliberations at once raised a host of important, thorny questions. The emancipation was not merely a humanitarian question capable of being solved instantaneously by imperial ukaz. It contained very complicated problems affecting deeply the economic, social, and political future of the nation. Alexander II. had little of the special knowledge required for dealing successfully with such problems, and he had to restrict himself to choosing between the different measures recommended to him. The main point at issue was whether the serfs should become agricultural labourers dependent economically and administratively on the landlords, or should be transformed into a class of independent communal proprietors. The emperor gave his support to the latter project, and the Russian peasantry accordingly acquired rights and privileges such as are enjoyed by no other peasantry in Europe. In the numerous other questions submitted to him he began by consulting carefully the conflicting authorities, and while leaning as a rule rather to the side of those who were known as "Liberals," he never went so far as they desired, and always sought some middle course by which conflicting interests might be reconciled. On the 3rd of March 1861, the sixth anniversary of his accession, the emancipation law was signed and published. Other reforms followed in quick succession during the next five or six years: army and navy organization, a new judicial administration on the French model, a new penal code and a greatly simplified system of civil and criminal procedure, an elaborate scheme of local self-government for the rural districts and the large towns, with elective assemblies possessing a restricted right of taxation, and a new rural and municipal police under the direction of the minister of the interior. These new institutions were incomparably better than the old ones which they replaced, but they did not work such miracles as inexperienced enthusiasts expected. Comparisons were made, not with the past, but with an ideal state of things which never existed in Russia or elsewhere. Hence arose a general feeling of disappointment, which acted on different natures in different ways. Some of the enthusiasts sank into a sceptical, reactionary frame of mind; while others, with deeper convictions or capable of more lasting excitement, attributed the failure to the fact that only half-measures and compromises had been adopted by the Government. Thus appeared in the educated classes two extreme groups: on the one hand, the discontented Conservatives, who recommended a return to a more severe disciplinarian *régime;* and on the other, the discontented Radicals, who would have been satisfied with nothing less than the adoption of a thoroughgoing socialistic programme. Between the two extremes stood the discontented Moderates, who indulged freely in grumbling without knowing how the unsatisfactory state of things was to be remedied. For some years the emperor, with his sound common-sense and dislike of exaggeration, held the balance fairly between the two extremes; but long years of uninterrupted labour, anxiety, and disappointment weakened his zeal for reform, and when radicalism assumed more and more the form of secret societies and revolutionary agitation, he felt constrained to adopt severe repressive measures.

The revolutionary agitation was of a very peculiar kind. It was confined to a section of the educated classes, and emanated from the universities and higher technical schools. At the beginning of the reform period there had been much enthusiasm for scientific as opposed to classical education. Russia required, it was said, not classical scholars, but practical, scientific men, capable of developing her natural resources. The Government, in accordance with this view, had encouraged scientific studies until it discovered to its astonishment that there was some

Nihilism.

mysterious connexion between natural science and revolutionary tendencies. Many of the young men and women, who were supposed to be qualifying as specialists in the various spheres of industrial and commercial enterprise, were in reality devoting their time to considering how human society in general, and Russian society in particular, could be reconstructed in accordance with the latest physiological, biological, and sociological principles. Some of these young people wished to put their crude notions immediately into practice, and as their desire to make gigantic socialist experiments naturally alarmed the Government, their activity was opposed by the police. Many of them were arrested and imprisoned or exiled to distant provinces, but the revolutionary work was continued with unabated zeal. Thus arose a struggle between the youthful, hot-headed partisans of revolutionary physical science and the zealous official guardians of political order—a struggle which has made the strange term Nihilism a familiar word not only in Russia but also in Western Europe. The movement gradually assumed the form of terrorism, and aimed at the assassination of prominent officials, and even of the emperor himself, and the natural result was that the reactionary tendencies of the Government were strengthened.

Foreign policy.

In foreign policy Alexander II. showed the same qualities of character as in internal affairs, ever trying prudently to steer a middle course. When he came to the throne, a peace policy was imposed on him by circumstances. The Crimean war was still going on, but as there was no doubt as to the final issue, and the country was showing symptoms of exhaustion, he concluded peace with the Allies as soon as he thought the national honour had been satisfied. Prince Gortchakoff could then declare to Europe, "*La Russie ne boude pas; elle se recueille*"; and for fifteen years he avoided foreign complications, so that the internal strength of the country might be developed, while the national pride and ambition received a certain satisfaction by the expansion of Russian influence and domination in Asia. Twice, indeed, during that period the chancellor ran the risk of provoking war. The first occasion was in 1863, when the Western Powers seemed inclined to interfere in the Polish question, and the Russian chancery declared categorically that no interference would be tolerated. The second occasion was during the Franco-German war of 1870-71, when the Cabinet of St Petersburg boldly declared that it considered itself no longer bound by the Black Sea clause of the Treaty of Paris. On both these occasions hostilities were averted. Not so on the next occasion, when Russia abandoned her attitude of *recueillement*. When the Eastern Question was raised in 1875 by the insurrection of Herzegovina, Alexander II. had no intention or wish to provoke a great European war. No doubt he was waiting for an opportunity of recovering the portion of Bessarabia which had been ceded by the Treaty of Paris, and he perceived in the disturbed state of Eastern Europe a possibility of obtaining the desired rectification of frontier, but he hoped to effect his purpose by diplomatic means in conjunction with Austria. At the same time he was anxious to obtain for the Christians of Turkey some amelioration of their condition, and to give thereby some satisfaction to his own subjects. As autocratic ruler of the nation which had long considered itself the defender of the Eastern Orthodox faith and the protector of the Slav nationalities, he could not remain inactive at such a crisis, and he gradually allowed himself to drift into a position from which he could not retreat without obtaining some tangible result. Supposing that the Porte would yield to diplomatic pressure and menace so far as to make some reasonable concessions, he delivered his famous Moscow speech, in which he declared that if Europe would not secure a better position for the oppressed Slavs he would act alone. The diplomatic pressure failed, and war became inevitable. During the campaign he displayed the same perseverance and the same moderation that he had shown in the emancipation of the serfs. To those who began to despair of success, and advised him to conclude peace on almost any terms so as to avoid greater disasters, he turned a deaf ear, and brought the campaign to a successful conclusion; but when his more headstrong advisers urged him to insist on terms which would probably have produced a conflict with Great Britain and Austria, he resolved, after some hesitation, to make the requisite concessions. In this resolution he was influenced by the discovery that he could not rely on the expected support of Germany, and the discovery made him waver in his devotion to the German alliance, which had been the main pivot of his foreign policy; but his personal attachment to the Emperor William prevented him from adopting a hostile attitude towards the empire he had helped to create.

The patriotic excitement produced by the war did not weaken the revolutionary agitation. The struggle between the Terrorists and the police authorities became more and more intense, and attempts at assassination became more and more frequent. Alexander II. succumbed by degrees to the mental depression produced originally by the disappointments which he experienced in his home and foreign policy; and in 1880, when he had reigned twenty-five years, he entrusted to Count Loris-Melikof a large share of the executive power. In that year the empress died, and a few weeks afterwards he married secretly a Princess Dolgoruki, with whom he had already entertained intimate relations for some years. Early in 1881, on the advice of Count Loris-Melikof, he determined to try the effect of some moderate liberal reforms on the revolutionary agitation, and for this purpose he caused an ukaz to be prepared creating special commissions, composed of high officials and private personages who should prepare reforms in various branches of the administration. On the very day on which this ukaz was signed—13th March 1881—he fell a victim to a Nihilist plot. When driving in one of the central streets of St Petersburg, near the Winter Palace, he was mortally wounded by the explosion of some small bombs, and died a few hours afterwards.

(D. M. W.)

Alexander III. (1845-1894), emperor of Russia, second son of Alexander II., was born on 10th March 1845. In natural disposition he bore little resemblance to his soft-hearted, liberal-minded father, and still less to his refined, philosophic, sentimental, chivalrous, yet cunning grand-uncle Alexander I., who coveted the title of "the first gentleman of Europe." With high culture, exquisite refinement, and studied elegance he had no sympathy, and never affected to have any. Indeed, he rather gloried in the idea of being of the same rough texture as the great majority of his subjects. His straightforward, abrupt manner savoured sometimes of gruffness, while his direct, unadorned method of expressing himself harmonized well with his rough-hewn, immobile features and somewhat sluggish movements. His education was not fitted to soften these peculiarities. During the first twenty years of his life he had no prospect of succeeding to the throne, because he had an elder brother, Nicholas, who seemed of a fairly robust constitution. Even when this elder brother showed symptoms of delicate health it was believed that his life might be indefinitely prolonged by proper care and attention, and precautions had been taken for the succession by his betrothal with the Princess Dagmar of Denmark. In these circumstances the greatest solicitude was devoted to the education of Nicholas as cesarevitch, whereas Alexander received only the perfunctory and inadequate training of an ordinary grand duke of that period, which did not go much beyond primary and secondary instruction, practical acquaintance with French, English, and German, and a certain amount of drill. When he became heir-apparent by the death of his elder brother in 1865, he began to study the principles of law and administration under Professor Podêdonostsef, who did not succeed in awakening in his pupil a love of abstract studies or prolonged intellectual exertion, but who influenced the character of his reign by instilling into his mind the belief that zeal for Eastern Orthodoxy ought, as an essential factor of Russian patriotism, to be specially cultivated by every right-minded Tsar. His elder brother when on his deathbed had expressed a wish that his affianced bride, Princess Dagmar of Denmark, should marry his successor, and this wish was realized on 9th November 1866. The union proved a most happy one and remained unclouded to the end. During those years when he was heir-apparent—1865 to 1881—he did not play a prominent part in public affairs, but he allowed it to become known that he had certain ideas of his own which did not coincide with the principles of the existing Government. He deprecated what he considered undue foreign influence in general, and German influence in particular, and he longed to see the adoption of genuine national principles in all spheres of official activity, with a view to realizing his ideal of a homogeneous Russia—homogeneous in language, administration, and religion. With such ideas and aspirations he could hardly remain permanently in cordial agreement with his father, who, though a good patriot according to his lights, had strong German sympathies, often used the German language in his private relations, occasionally ridiculed the exaggerations and eccentricities of the Slavophils, and based his foreign policy on the Prussian alliance. The antagonism first appeared publicly during the Franco-German war, when the Tsar supported the Cabinet of Berlin and the cesarevitch did not conceal his sympathies with the French. It reappeared in an intermittent fashion during the years 1875-79, when the Eastern Question produced so much excitement in all ranks of Russian society. At first the cesarevitch was more Slavophil than the Government, but his phlegmatic nature preserved him from many of the exaggerations indulged in by others, and any of the prevalent popular illusions he may have imbibed were soon dispelled by personal observation in Bulgaria, where he commanded the left wing of the invading army. The Bulgarians had been represented in St Petersburg and Moscow not only as martyrs but also as saints, and a very little personal experience sufficed to correct the error. Like most of his brother officers he could not feel any very great affection for the "little brothers," as the Bulgarians were then commonly called, and be was constrained to admit that the Turks were by no means so black as they had been painted. He did not, however, scandalize the believers by any public expression of his opinions, and did not indeed make himself conspicuous in any way during the campaign. Never consulted on political questions, he confined himself to his military duties, and fulfilled them in a conscientious and unobtrusive manner. After many mistakes and disappointments, the army reached Constantinople and the treaty of San Stefano was signed, but much that had been obtained by that important document had to be sacrificed at the Congress of Berlin. Prince Bismarck failed to do what was confidently expected of him. In return for the Russian support, which had enabled him to create the German empire, it was thought that he would help Russia to solve the Eastern Question in accordance with her own interests, but to the surprise and indignation of the Cabinet of St Petersburg he confined himself to acting the part of "honest broker" at the Congress, and shortly afterwards he ostentatiously contracted an alliance with Austria for the express purpose of counteracting Russian designs in Eastern Europe. The cesarevitch could point to these results as confirming the views he had expressed during the Franco-German war, and he drew from them the practical conclusion that for Russia the best thing to do was to recover as quickly as possible from her temporary exhaustion and to prepare for future contingencies by a radical scheme of military and naval reorganization. In accordance with this conviction, he suggested that certain reforms should be introduced. During the campaign in Bulgaria he had found by painful experience that grave disorders and gross corruption existed in the military administration, and after his return to St Petersburg he had discovered that similar abuses existed in the naval department. For these abuses, several high-placed personages—among others two of the grand dukes—were believed to be responsible, and he called his father's attention to the subject. His representations were not favourably received. Alexander II. had lost much of the reforming zeal which distinguished the first decade of his reign, and had no longer the energy required to undertake the task suggested to him. The consequence was that the relations between father and son became more strained. The latter must have felt that there would be no important reforms until he himself succeeded to the direction of affairs. That change was much nearer at hand than was commonly supposed. On 13th March 1881, Alexander II. was assassinated by a band of Nihilists, and the autocratic power passed to the hands of his son.

Alexander III.

In the last years of his reign, Alexander II. had been much exercised by the spread of Nihilist doctrines, and the increasing number of anarchist conspiracies, and for some time he had hesitated between strengthening the hands of the executive and making concessions to the widespread political aspirations of the educated classes. Finally he decided in favour of the latter course, and on the very day of his death he signed an ukaz, creating a number of consultative commissions which might have been easily transformed into an assembly of notables. Alexander III. determined to adopt the opposite policy. He at once cancelled the ukaz before it was published, and in the manifesto announcing his accession to the throne he let it be very clearly understood that he had no intention of limiting or weakening the autocratic power which he had inherited from his ancestors. Nor did he afterwards show any inclination to change his mind. All the internal reforms which he initiated were intended to correct what he considered as the too liberal tendencies of the previous reign, so that he left behind him the reputation of a sovereign of the retrograde type. In his opinion Russia was to be saved from anarchical disorders and revolutionary agitation, not by the parliamentary institutions and so-called liberalism of Western Europe, but by the three principles which the elder generation of the Slavophils systematically recommended—nationality, Eastern Orthodoxy, and autocracy. His political ideal was a nation containing only one nationality, one language, one religion, and one form of administration; and he did his utmost to prepare for the realization of this ideal by imposing the Russian language and Russian schools on his German, Polish, and Finnish subjects, by fostering Eastern Orthodoxy at the expense of other confessions, by persecuting the Jews, and by destroying the remnants of German, Polish, and Swedish institutions in the outlying provinces. In the other provinces he sought to counteract what he considered the excessive liberalism of his father's reign. For this purpose he clipped the feeble wings of the Zemstvo, an elective local administration resembling the county and parish councils in England, and placed the autonomous administration of the peasant communes under the supervision of landed proprietors appointed by the Government. At the same time he sought to strengthen and centralize the imperial administration, and to bring it more under his personal control. In foreign affairs he was emphatically a man of peace, but not at all a partisan of the doctrine of peace at any price, and he followed the principle that the best means of averting war is to be well prepared for it. Though indignant at the conduct of Prince Bismarck towards Russia, he avoided an open rupture with Germany, and even revived for a time the Three Emperors' Alliance. It was only in the last years of his reign, when M. Katkoff had acquired a certain influence over him, that he adopted towards the Cabinet of Berlin a more hostile attitude, and even then he confined himself to keeping a large quantity of troops near the German frontier, and establishing cordial relations with France. With regard to Bulgaria he exercised similar self-control. The efforts of Prince Alexander and afterwards of M. Stamboloff to destroy Russian influence in the principality excited his indignation, but he persistently vetoed all proposals to intervene by force of arms. In Central Asian affairs he followed the traditional policy of gradually extending Russian domination without provoking a conflict with Great Britain, and he never allowed the bellicose partisans of a forward policy to get out of hand. As a whole his reign cannot be regarded as one of the eventful periods of Russian history; but it must be admitted that, under his hard, unsympathetic rule, the country made considerable progress. He died at Livadia on 1st November 1894, and was succeeded by his eldest son, Nicholas II.

(D. M. W.)

Alexander of Battenberg (1857-1893), first Prince of Bulgaria, was the second son of Prince Alexander of Hesse and the Rhine by his morganatic marriage with Julia, Countess von Hauke. The title of Battenberg, derived from an ancient residence of the grand-ducal family of Hesse, was conferred, with the prefix *Durchlaucht* or "Serene Highness," on the countess and her descendants in 1858. Prince Alexander, who was born 5th April 1857, was nephew of the Tsar Alexander II., who had married a sister of Prince Alexander of Hesse; his mother, a daughter of Count Moritz von Hauke, had been lady-in-waiting to the Tsaritsa. In his boyhood and early youth he was frequently at St Petersburg, and he accompanied his uncle, who was much attached to him, during the Bulgarian campaign of 1877. When Bulgaria under the Berlin Treaty was constituted an autonomous principality under the suzerainty of Turkey, the Tsar recommended his nephew to the Bulgarians as a candidate for the newly-created throne, and Prince Alexander was elected prince of Bulgaria by unanimous vote of the Grand Sobranye, 29th April 1879. He was at that time serving as a lieutenant in the Prussian life-guards at Potsdam. Before proceeding to Bulgaria, Prince Alexander paid visits to the Tsar at Livadia, to the courts of the Great Powers, and to the Sultan; he was then conveyed on a Russian warship to Varna, and after taking the oath to the new constitution at Tirnova (8th July 1879) he repaired to Sofia, being everywhere greeted with immense enthusiasm by the people. (For the political history of Prince Alexander's reign, see Bulgaria.) Without any previous training in the art of government, the young prince from the outset found himself confronted with difficulties which would have tried the sagacity of an experienced ruler. On the one hand he was exposed to numberless humiliations on the part of the representatives of official Russia, who made it clear to him that he was expected to play the part of a *roi fainéant;* on the other he was compelled to make terms with the Bulgarian politicians, who, intoxicated with newly-won liberty, prosecuted their quarrels with a crude violence which threatened to subvert his authority and to plunge the nation in anarchy. After attempting to govern under these conditions for nearly two years, the prince, with the consent of the Tsar Alexander III., assumed absolute power (9th May 1881), and a suspension of the ultra-democratic constitution for a period of seven years was voted by a specially convened assembly (13th July). The experiment, however, proved unsuccessful; the Bulgarian Liberal and Radical politicians were infuriated, and the real power fell into the hands of two Russian generals, Soboleff and Kaulbars, who had been specially despatched from St Petersburg. The prince, after vainly endeavouring to obtain the recall of the generals, restored the constitution with the concurrence of all the Bulgarian political parties (18th September 1883). A serious breach with Russia followed, which was widened by the part which the prince subsequently played in encouraging the national aspirations of the Bulgarians. The revolution of Philippopolis (18th September 1885), which brought about the union of Eastern Rumelia with Bulgaria, was carried out with his consent, and he at once assumed the government of the revolted province. In the anxious year which followed, the prince gave evidence of considerable military and diplomatic ability. He rallied the Bulgarian army, now deprived of its Russian officers, to resist the Servian invasion, and after a brilliant victory at Slivnitza (19th November) pursued King Milan into Servian territory as far as Pirot, which he captured (27th November). Although Servia was protected from the consequences of defeat by the intervention of Austria, Prince Alexander's success sealed the union with Eastern Rumelia, and after long negotiations he was nominated governor-general of that province for five years by the Sultan (5th April 1886). This arrangement, however, cost him much of his popularity in Bulgaria, while discontent prevailed among a certain number of his officers, who considered themselves slighted in the distribution of rewards at the close of the campaign. A military conspiracy was formed, and on the night of the 20th August the prince was seized in the palace at Sofia, and compelled to sign his abdication; he was then hurried to the Danube at Rakhovo, transported on his yacht to Reni, and handed over to the Russian authorities, by whom he was allowed to proceed to Lemberg. He soon, however, returned to Bulgaria, owing to the success of the counter-revolution led by Stamboloff, which overthrew the provisional government set up by the Russian party at Sophia. But his position had become untenable, partly owing to an ill-considered telegram which he addressed to the Tsar on his return; partly in consequence of the attitude of Prince Bismarck, who, in conjunction with the Russian and Austrian Governments, forbade him to punish the leaders of the military conspiracy. He therefore issued a manifesto resigning the throne, and left Bulgaria on the 8th September 1886. He now retired into private life. A few years later he married Fräulein Loisinger, an actress, and assumed the style of Count Hartenau (6th February 1889). The last years of his life were spent principally at Gratz, where he held a local command in the Austrian army. Here, after a short illness, he died on the 23rd October 1893. His remains were brought to Sofia, where they received a public funeral, and were eventually deposited in a mausoleum erected in his memory. Prince Alexander possessed much charm and amiability of manner; he was tall, dignified, and strikingly handsome. His capabilities as a soldier have been generally recognized by competent authorities. As a ruler he committed some errors, but his youth and inexperience and the extreme difficulty of his position must be taken into consideration. He was not without aptitude for diplomacy, and his intuitive insight and perception of character sometimes enabled him to outwit the crafty politicians by whom he was surrounded. His principal fault was a want of tenacity and resolution; his tendency to unguarded language undoubtedly increased the number of his enemies.

The literature relating to Prince Alexander's reign is still scanty. See Drandar. *Le Prince Alexandre de Battenberg en Bulgarie.* Paris, 1884.—Koch. *Fürst Alexander von Bulgarien.* Darmstadt, 1887.—Matveyev. *Bulgarien nach dem Berliner Congress.* Petersburg, 1887.—Bourchier. "Prince Alexander of Battenberg," in *Fortnightly Review*, January 1894.

(J. D. B.)

Alexander, king of Servia (1876-——), was born 14th August 1876. He succeeded to the crown on 6th March 1889, when his father, King Milan, abdicated and proclaimed him king of Servia under a regency until he should attain his majority at eighteen years of age. King Alexander on 13th April 1893, being then in his seventeenth year, made his notable *coup d'état* and took the royal authority into his own hands. After a banquet on that day he made a stirring appeal to the army, proclaimed his majority, and dismissed the regents and their ministry. His action was popular, and was rendered still more so by his appointment of a Radical ministry. In May 1894 King Alexander, by another *coup d'état*, abolished the constitution of 1889 and restored that of 1869, thus reinstating King Milan and Queen Natalie in their constitutional rights as members of the royal house of Obrenovitch. His attitude during the Turco-Greek war of 1897 was one of strict neutrality. In 1898 he appointed his father commander-in-chief of the Servian army, and from that time, or rather from his return to Servia in 1894 until 1900 ex-King Milan was regarded as the *de facto* ruler of the country. But on 21st July 1900 King Alexander publicly betrothed himself to Madame Draga Maschin, a widow, formerly a lady-in-waiting to Queen Natalie. The projected union aroused great opposition at first, and ex-King Milan resigned his post, an example followed by all the government officials; the marriage, however, was duly celebrated on 5th August, and the king's firmness in the matter greatly strengthened his position, which was made even more secure by the death of his father shortly afterwards.

Alexander, William (1824-——), Protestant Archbishop of Armagh and Primate of all Ireland, was born at Londonderry 13th April 1824, and educated at Tonbridge Grammar School and at Exeter and Brasenose colleges, Oxford. After holding several livings in the north of Ireland he was made bishop of Derry and Raphoe in 1867, and was elevated to the primacy in 1896. An eloquent preacher and the author of numerous theological works, he is best known to literature as a master of dignified and animated verse. His poems were collected in 1887 under the title of *St Augustine's Holiday, and other Poems.* His wife, who died in 1895, was also known as a writer of graceful poetry, and particularly for her hymn "There is a Green Hill far away."

Alexandra, Queen. See Edward VII.

Alexandretta, or Iskanderún (*Alexandria ad Issum*), the principal port of the Aleppo vilâyet, founded by Alexander in memory of the battle of Issus. The town was formerly unhealthy, but since the drainage of the marshes and the provision of a better water-supply, its sanitary condition has greatly improved and trade is increasing. Population, 8000 (Moslems, 5500; Christians, 2500). It is the seat of a British vice-consulate. See Aleppo.

Alexandria, the chief seaport and, next to Cairo, the largest city in Egypt. It suffered severely during the revolt of Arabi Pasha in June and July 1882, when, both before and after the bombardment of the forts by the British fleet, great disorders broke out in the town. On 11th June over 400 Europeans were massacred by the fanatical Mahommedans, and on the night following the bombardment (11th July) incendiary riots caused great loss of life and property, for which Egypt had eventually to raise £9,000,000 to meet the claims for compensation made chiefly by Europeans. Since then it has been visited by two epidemics of cholera (1883 and 1897). Nevertheless under the British occupation it has recovered its former commercial and industrial prosperity, as shown by the rapid increase of the population, which rose from 213,000 in 1882 to 320,000 in 1897, including over 46,000 Europeans, chiefly Greeks and Italians, and about 100 English families. Most of the foreign trade of Egypt passes through this seaport, the imports and exports of which advanced from £5,000,000 and £13,000,000 respectively in 1881 to £9,945,000 and £15,068,000 in 1899. The vessels entered were 3305 of 1,192,000 tons in 1881, and 2805 of 2,414,674 tons in 1899; the clearances for the corresponding years being 3250 of 1,304,000 tons and 2758 of 2,389,058 tons. In 1899 the British entries were 747 of 1,150,231 tons, and clearances 741 of 1,139,698 tons. Alexandria was the first Egyptian town provided with a municipal council, on which the government, the foreign merchants, and natives are represented. A great deal has been done to improve the town, which is provided with several new thoroughfares, electric light, and electric tramways, while the suburb of Ramleh has been greatly enlarged, and is now occupied chiefly by English residents. A new quay and promenade, extensive wharves and graving docks are also being constructed, while a projected channel 30 feet deep and 300 wide will enable large vessels to enter the port at all times. Amongst the scientific and literary establishments are the Egyptian institute, an athenæum, with courses of lectures, a public library, and an archæological museum. In the last-mentioned, founded in 1893, are now safely housed the antiquities, especially Greek and Roman, which are from time to time brought to light in the district. During the excavations near Pompey's column in 1900 some monumental ruins were exposed, which have by some archæologists been identified with the foundations of the great temple of Serapis. Alexandria is held by a British garrison of about 1000 men, including a battalion of infantry and artillery, under a British major-general.

Alexandria, a town in Rumania, situated in a rich grain-producing country, near the Danube, between Roshi-de-Vede and Zimnitza. It was founded by Prince Alexander Couza. Population (1900), 13,675.

Alexandria, a district town of Russia, government of Kherson, 93 miles S.W. of Poltava, on the Ingulets, with tanneries, tallow-houses, and soap and candle works. Population (1897), 14,002.

Alexandria, a manufacturing town of Dumbartonshire, Scotland, situated on the right bank of the river Leven, opposite Bonhill, by rail 19¼ miles W.N.W. of Glasgow. It contains the largest of the five Turkey red-dyeing establishments recently amalgamated under one company. The public buildings include a public hall, the mechanics' institute library, an institute for men, with library and recreation rooms, and a similar institution for women. Population in 1881, 6173; 1891, 7796; 1901, 8392. Alexandria is in the parish of Bonhill, with the town of which name it is connected by a bridge which replaced in 1898 one bought three years earlier by the County Council from the Smollett family. Population of Bonhill town in 1901, 3922; of Bonhill parish, 14,581.

Alexandria, a city of Virginia, U.S.A., situated in 38° 48′ N. lat. and 77° 02′ W. long. Though within the limits of Alexandria county, it is independent of county government, is divided into four wards, and is entered by the Pennsylvania and the Southern railways, and by electric railway from Washington, with which it is also connected by ferry. The Civil War checked its growth, and the powerful rivalry of Washington, only seven miles distant, has held it almost at a standstill for a generation. The Chesapeake and Ohio Canal, which formerly extended to this place, now ends at Washington. The population in 1880 was 13,659, in 1890 it was 14,339, and in 1900 it was 14,528.

Alexandria, a city of Madison county, Indiana, U.S.A., a little north-east of the centre of the state, at the intersection of the Cleveland, Cincinnati, Chicago, and St Louis and the Lake Erie and Western railways. It has had a rapid growth, the population increasing from 715 in 1890 to 7221 in 1900.

Alexandria, a town of Louisiana, U.S.A., capital of Rapides Parish, on the south bank of the Red river, in the central part of the state, in a region devoted to the cultivation of sugar-cane and cotton. The population in 1890 was 2861; in 1900 it was 5648.

Alexandropol, or Alexandrapol (Turkish *Guleri*), a Russian town, fortress, and fortified camp in Transcaucasia, government of Erivan, near the junction of the Arpachai with the Aras, 30 miles by rail E.N.E. of Kars. It has an extensive fortified military camp, and six spacious caravanserais, besides considerable silk trade. Population (1885), 22,670; (1897), 32,020.

Alexandrovsk, the name of several towns in Russia: (1) New settlement of the government of Archangel, in the military harbour of Catherine (Ekaterininsk), on the Norman coast, 5 miles from the mouth of Kola Bay and 26 miles from Kola. It is a naval station. (2) District and town south of Ekaterinoslav, near the left bank of the Dnieper, below its rapids, and on the railway to Sebastopol. It has great store-houses. Population (1897), 16,393. Opposite it is the island of Khortitsa, upon which was the renowned Sich (or Syech) of the Zaporogue Cossacks. All its neighbourhood is strewn with *kurgans* (tumuli). (3) Russian village and fort, on the coast of the maritime province in Gulf De Castries, opposite Sakhalin island. It has a good harbour, hospital, and government store-houses, and trade with America.

Alexandrovsk-Grushevskaya, a Cossack village of Russia, province of the Don, 5 miles N.W. of Novocherkask, in the centre of the Grushevskiya anthracite mines. The stock of coal of the latter is estimated at 16,000,000 tons. About 645,000 tons are now extracted every year by about 13,100 workmen. Population of the village, 16,250 in 1897.

Alfortville, a town, arrondissement of Sceaux, department of Seine, 4 miles E.S.E. of Paris, at the confluence of the Seine and the Marne. India-rubber goods are manufactured, boat-building is carried on, and there are forges and rolling-mills. Population (1891), 7735; (1896), 11,410, (comm.) 11,614.

Alfred Ernest Albert, Duke of Edinburgh, and Duke of Saxe-Coburg and Gotha, (1844-1900), second son and fourth child of Queen Victoria, was born at Windsor Castle, 6th August 1844. In 1856 it was decided that the prince, in accordance with his own wishes, should enter the navy, and a separate establishment was accordingly assigned to him, with Sir John Cowell as governor. He passed a most creditable examination for midshipman in August 1858, and being appointed to the *Euryalus*, at once began to work hard at the practical part of his profession. In July 1860, while on this ship, he paid an official visit to the Cape, and made a very favourable impression both on the colonials and on the native chiefs. On the abdication of Otho, king of Greece, in 1862, Prince Alfred was chosen by the whole people to succeed him, but political conventions of long standing rendered it impossible for the British Government to accede to their wishes. The prince therefore remained in the navy, and was promoted lieutenant 24th February 1863, and captain 23rd February 1866, being then appointed to the command of the *Galatea*. On attaining his majority in 1865, the prince was created duke of Edinburgh and earl of Ulster, with an annuity of £15,000 granted by Parliament. While still in command of the *Galatea*, the duke started from Plymouth, 24th January 1867, for his voyage round the world. On 11th June 1867 he left Gibraltar and reached the Cape on 24th July, and landed at Glenelg, South Australia, on 31st October. Being the first royal prince to visit Australia, the duke was received with the greatest enthusiasm. During his stay of nearly five months he visited Adelaide, Melbourne, Sydney, Brisbane, and Tasmania; and it was on his second visit to Sydney that, while attending a public picnic at Clonfert in aid of the Sailors' Home, an Irishman named O'Farrell shot him in the back with a revolver. The wound was fortunately not dangerous, and within a month the duke was able to resume command of his ship and return home. He reached Spithead on 26th June 1868, after an absence of seventeen months. The duke's next voyage was to India, where he arrived in December 1869. Both there and at Hong Kong, which he visited on the way, he was the first British prince to set foot in the country. The native rulers of India vied with one another in the magnificence of their entertainments during the duke's stay of three months. On 23rd January 1874 the marriage of the duke to the Grand Duchess Marie Alexandrovna, only daughter of Alexander II., emperor of Russia, was celebrated at St. Petersburg, and the bride and bridegroom made their public entry into London on 12th March. The duke still devoted himself to his profession, showing complete mastery of his duties and unusual skill in naval tactics. He was promoted rear-admiral, 30th December 1878; vice-admiral, 10th November 1882; admiral, 18th October 1887; and received his baton as admiral of the Fleet, 3rd June 1893. He commanded the Channel Fleet, 1883-84; the Mediterranean Fleet, 1886-89; and was commander-in-chief at Devonport, 1890-93. He always paid the greatest attention to his official duties, and was most efficient as an admiral.

On the death of his uncle, Ernest II., duke of Saxe-Coburg and Gotha, 22nd August 1893, the vacant duchy fell to the duke of Edinburgh, for the Prince of Wales had renounced his right to the succession. At first regarded with some coldness as a "foreigner," he gradually gained popularity, and by the time of his death, 30th July 1900, he had completely won the good opinion of his subjects. The duke was exceedingly fond of music, and an excellent violinist, and took a prominent part in establishing the Royal College of Music. He was also a keen collector of glass and ceramic ware, and his collection, valued at half a million of marks, was presented by his widow to the "Veste Coburg," near Coburg. When he became duke of Saxe-Coburg he surrendered his English allowance of £15,000 a year, but the £10,000 granted in addition by Parliament on his marriage he retained in order to keep up Clarence House. The duke had one son, who died unmarried, 6th February 1899, and four daughters. The third daughter, Princess Alexandra Louisa Olga Victoria, married the hereditary Prince Ernest of Hohenlohe-Langenburg, who became regent of the duchy of Coburg during the minority of the deceased duke's nephew, the young duke of Albany, to whom the succession fell. (G. F. B.)

ALGÆ.

Classification.

THE Latin word *Alga* seems to have been the equivalent of the English word "seaweed," and probably stood for any or all of the species of plants which form the "wrack" of a seashore. When the word "Algæ" came to be employed in classification as the name of a class, an arbitrary limitation had to be set to its signification, and this was not always in keeping with its original meaning. The absence of differentiation into root, stem, and leaf, which prevails among seaweeds, seems, for example, to have led Linnæus to employ the term in the *Genera Plantarum* for a subclass of *Cryptogamia*, the members of which presented this character in a greater or less degree. Of the fifteen genera included by Linnæus among Algæ, not more than six, viz.:—*Chara*, *Fucus*, *Ulva*, and *Conferva*, and in part *Tremella* and *Byssus*, would to-day, in any sense in which the term is employed, be regarded as Algæ. The excluded genera are distributed among the Liverworts, Lichens, and Fungi; but notwithstanding the great advance in knowledge since the time of Linnæus, the difficulty of deciding what limits to assign to the group to be designated *Algæ* still remains. It arises from the fact that Algæ, as generally understood, do not constitute a homogeneous group, suggesting a descent from a common stock. Among them there exist, as will be seen hereafter, many well-marked but isolated natural groups, and their inclusion in the larger group is generally felt to be a matter of convenience rather than the expression of a belief in their close inter-relationship. Efforts are therefore continually being made by successive writers to exclude certain outlying sub-groups, and to reserve the term *Algæ* for a central group reconstituted on a more natural basis within narrower limits.

It is perhaps desirable, in an article like this, to treat of Algæ in the widest possible sense in which the term may be used, an indication being at the same time given of the narrower senses in which it has been proposed to employ it. Interpreted in this way, the place of Algæ in the vegetable kingdom may be shown by means of a table:—

- The Vegetable Kingdom
  - *Cryptogamia*
    - *Thallophyta*
      - *Myxomycetes*
      - *Fungi*
      - *Algæ*
    - *Bryophyta*
    - *Pteridophyta*
  - *Phanerogamia*
    - Gymnosperms
    - Angiosperms

Algæ in this wide sense may be briefly described as the aggregate of those simpler forms of plant life usually devoid, like the rest of the *Thallophyta*, of differentiation into root, stem, and leaf; but, unlike other *Thallophyta*, possessed of a colouring matter, by means of which they are enabled, in the presence of sunlight, to make use of the carbonic acid gas of the atmosphere as a source of carbon. It is true that certain *Bryophyta* (*Marchantiaceæ*, *Anthoceroteæ*) possess a thalloid structure similar to that of *Thallophyta*, and are at the same time possessed of the colouring matter of the Green Algæ. Their life-cycle, however, the structure of the reproductive organs, and their whole organization proclaim them to be *Bryophyta*. (See MUSCINEÆ, ninth ed., and BRYOPHYTA.) On the other hand certain undoubted animals (*Stentor*, *Hydra*, *Bonellia*) are provided with a green colouring matter by means of which they make use of atmospheric carbonic acid. A more important consideration is the occasional absence of this colour in species, or groups of species, with, in other respects, Algal affinities. Such aberrant forms are to be regarded in the same light as *Cuscuta* and *Orobanchaceæ*, for example, among Phanerogams. As these non-green plants do not cease to be classed with other Phanerogams, so must the forms in question be retained among Algæ. In all cases the loss of the colouring matter is associated with an incapacity to take up carbon from so simple a compound as carbonic acid.

Further discussion of the general characters of Algæ will be deferred in order to take a brief survey of the subdivisions of the group. For this purpose, there will be adopted the classification of Algæ into four sub-groups, founded on the nature of the colouring matters present in the plant:—

1. CYANOPHYCEÆ, or Blue-green Algæ.
2. CHLOROPHYCEÆ, or Green Algæ.
3. PHÆOPHYCEÆ, or Brown Algæ.
4. RHODOPHYCEÆ, or Red Algæ.

The merits and demerits of this system will appear during the description of the characters of the members of the several subdivisions.

1. CYANOPHYCEÆ.[1]—This group derives its name from the circumstance that the cells contain in addition to the green colouring matter, chlorophyll, a blue-green colouring matter to which the term phycocyanin has been applied. To the eye, however, members of this group present a greater variety of colour

---

[1] Includes (exclusive of Bacteriaceæ):—
1. *Coccogoneæ*—2 families, 29 genera, 253 species.
2. *Hormogoneæ*—6 families, 59 genera, 701 species.
(Engler and Prantl's *Pflanzenfamilien*).

Sub-divisions.

than those of any other—yellow, brown, olive, red, purple, violet and variations of all these being known. They undoubtedly represent the lowest grade of Algal life, and their distribution rivals that of the Green Algæ. They occur in the sea, in fresh water, on moist earth, on damp rocks, and on the bark of trees. Certain species are regularly found in the intercellular spaces of higher plants; such are species of *Nostoc* in the thallus of *Anthoceros*, the leaves of *Azolla*, and the roots of Cycads. Many of them enter into the structure of the lichen-thallus, as the so-called gonidia. It is remarkable that species belonging to the *Oscillatoriaceæ* are known to flourish in hot springs, the temperature of which rises as high as 85° C.

The thallus may be unicellular or multicellular. When unicellular, it may consist of isolated cells, but more commonly the cells are held together in a common jelly (*Chroococcaceæ*) derived from the outer layers of the cell-wall. The multicellular species consist of filaments, branched or unbranched, which arise by the repeated division of the cells in parallel planes, no formation of mucilage occurring in the dividing walls. Such filaments may not give rise to mucilage on the lateral surface either, in which case they are said to be free; when mucilage does occur on the lateral wall, it appears as the sheath surrounding either the single filament, or a sheaf of filaments of common origin. The mucilage may also form an embedding substance similar to that of *Chroococcaceæ*, in which the filaments lie parallel or radiate from a common centre (*Rivulariaceæ*). The cells of the filament may be all alike, and growth may occur equally in all parts (*Oscillatoriaceæ*); or certain cells (heterocysts) may become marked off by their larger size and the transparency of their contents; in which case growth may still be distributed equally throughout (*Nostoc*), or the filament may be attached where the heterocyst arises, and grow out at the opposite extremity into a fine hair (*Rivulariaceæ*). An African form (*Camptothrix*), devoid of heterocysts and hair-like at both extremities, has recently been described. Branching has been described as "false" and "true." The former arises when a filament in a sheath, either in consequence of growth in length beyond the capacity of the sheath to accommodate it, or because of the decay of a cell, becomes interrupted by breaking, and the free ends slip past one another. "True" branching arises only by the longitudinal division of a cell of a filament and the lateral outgrowth of one of the cells resulting from the division (*Sirosiphonaceæ*).

The nature of the contents of the cells of *Cyanophyceæ* has given rise to considerable controversy. The cells are for the most part exceedingly minute, and are not easy to free from their colouring matters, so that investigation has been attended with great difficulty. Occupying as these Algæ do perhaps the lowest grade of plant life, it is a matter of interest to ascertain whether a nucleus or chromatophore is differentiated in their cells, or whether the functions and properties of these bodies are diffused through the whole protoplast. It is certain that the centre of the cell, which is usually non-vacuolated, is occupied by protoplasm of different properties from the peripheral region; and Fischer has farther established the fact that the peripheral mass, which is a hollow sphere in spherical cells, and either a hollow cylinder or barrel-shaped body in filamentous forms, must be regarded as the single chromatophore of the Cyanophyceous cell. But whether the central mass is anything more than protoplasm laden with the products of assimilation still remains uncertain. Among other contents of the cell, fatty substances and tannin are known. A curious adaptation seems to occur in certain floating forms, in the presence of a gas-vacuole, which may be made to vary its volume with varying pressure. There is evidence that the dividing wall of filamentous forms is deeply pitted, as is found to be the case in Red Algæ. Reproduction is chiefly effected by the vegetative method. Asexual reproductive cells are not infrequent, but sexual reproduction even in its initial stages is unknown. Nor is motility by means of cilia known in the group. In the unicellular forms, cell-division involves multiplication of the plant. In all the multicellular plants of this group which have been adequately investigated, vegetative multiplication by means of what are known as hormogonia has been found to occur. These are short segments of filaments consisting of a few cells which disengage themselves from the ambient jelly, if it be present, in virtue of a peculiar creeping movement which they possess at this stage. After a time they come to rest and give rise to new colonies. True reproduction of the asexual kind occurs, however, in the formation of sporangia, particularly in the *Chamæsiphonaceæ*. Here the contents of certain cells break up endogenously into a great number of spores, which are distributed as a fine dust. Resting spores are also known. In these cases, certain cells of a colony of unicellular plants or of the filaments of multicellular plants enlarge greatly and thicken their wall. When unfavourable external conditions supervene and the ordinary cells become atrophied, these cells persist and reproduce the plant with the return of more favourable conditions. The *Oscillatoriaceæ* are capable of a peculiar oscillatory movement, which has earned for them their name, and which enables them to move through considerable distances. It is not clear how the movement is effected, though it has frequently been the subject of careful investigation.

With the *Cyanophyceæ* must be included, as their nearest allies, the *Bacteriaceæ*. Notwithstanding the absence of chlorophyll, and the consequent parasitic or saprophytic habit, *Bacteriaceæ* agree in so many morphological features with *Cyanophyceæ* that the affinity can hardly be doubted.

They are, however, not further considered here, since they are separately dealt with in this work. (See BACTERIOLOGY.)

2. CHLOROPHYCEÆ.[1]—This group includes those Algæ in which the green colouring matter, chlorophyll, is not accompanied by a second colouring matter, as it is in other groups. It consists of three subdivisions:—*Conjugatæ*, *Euchlorophyceæ*, and *Characeæ*. Of these the first and last are relatively small and sharply-defined families, distinguished from the second family, which forms the bulk of the group, by characters so diverse that their inclusion with them in one larger group can only be justified on the ground of convenience. *Euchlorophyceæ* are made up in their turn of three series of families:—*Protococcales*, *Confervales*, and *Siphonales*. *Chlorophyceæ* include both marine and freshwater plants. *Conjugatæ*, *Protococcales*, and *Characeæ* are exclusively freshwater; *Confervales* and *Siphonales* are both freshwater and marine, but the latter group attains its greatest development in the sea. Some *Chlorophyceæ* are terrestrial in habit, usually growing on a damp substratum, however. *Trentepohlia* grows on rocks and can survive considerable desiccation. *Phycopeltis* grows on the surface of leaves, *Phyllobium* and *Phyllosiphon* in their tissues. *Gomontia* is a shell-boring Alga, *Dermatophyton* grows on the carapace of the tortoise, and *Trichophilus* in the hairs of the sloth. Certain *Protococcales* and *Confervales* exist as the gonidia of the lichen-thallus.

The thallus is of more varied structure in this group than in any other. In the simplest case it may consist of a single cell, which may remain free during the whole or the greater part of its existence, or be loosely aggregated together within a common mucilage, or be held together by the adhesion of the cell-walls at the surface of contact. These aggregations or colonies, as they are termed, may assume the form of a plate, a ring, a solid sphere, a hollow sphere, a perforate sphere, a closed net, or a simple or branched filament. It is not easy in all cases to draw a distinction between a colony of plants and a multicellular individual. In a *Volvox* sphere, for example, there is a marked protoplasmic continuity between all the cells of the colony. The *Ulvaceæ*, the thallus of which consists of laminæ one or more cells thick, or hollow tubes, probably represent a still more advanced stage in the passage of a colony into a multicellular plant. Here there is some amount of localization of growth and distinction of parts. It is only in such cases as *Volvox* and *Ulvaceæ* that there is any pretension to the formation of a true parenchyma within the limits of the *Chlorophyceæ*. In the whole series of the *Confervales*, the thallus consists of filaments branched or unbranched, attached at one extremity, and growing almost wholly at the free end. The branches end in fine hairs in *Chætophoraceæ*. In *Coleochætaceæ* the branches are often welded into a plate, simulating a parenchyma. In all *Conjugatæ* and most *Protococcales*, and in the bulk of the *Confervales*, the thallus consists of a cell or cells, the protoplast of which contains a single nucleus. In *Hydrodictyaceæ*, *Cladophoraceæ*, *Sphæropleaceæ*, and *Gomontiaceæ* this is no longer the case. Instead of a single relatively large nucleus, each cell is found to contain many small nuclei, and is spoken of as a *cœnocyte*. This character becomes still more pronounced in the large group of the *Siphonales*. *Valoniaceæ* and *Dasycladaceæ* are partially septate, but elsewhere no cellulose partitions occur, and the thallus is more or less the continuous tube from which the group is named. Yet the Siphonaceous Algæ may assume great variety of form and reach a high degree of differentiation. *Protosiphon* and *Botrydium*, on the one hand, are minute vesicles attached to muddy surfaces by rhizoids; *Caulerpa*, on the other, presents a remarkable instance of the way in which much the same external morphology as that of cormophytes has been reached by a totally different internal structure. Many *Siphonales* are encrusted with lime like *Corallina* among Red Algæ. *Penicillus* is brush-like, *Halimeda* and *Cymopolia* are jointed, *Acetabularia* has much the same external form as an expanded *Coprinus*, *Neomeris* simulates the fertile shoot of *Equisetum* with its densely-packed whorled branches, and in *Microdictyon*, *Anadyomene*, *Struvea*, and *Boodlea* the branches, spreading in one plane, become bound together in a more or less close network.

---

[1] Chlorophyceæ include:—
1. Confervoideæ—12 families, 77 genera, 1021 species.
2. Siphoneæ—9 families, 26 genera, 271 species.
3. Protococcoideæ—2 families, 90 genera, 342 species.
4. Conjugatæ—2 families, 33 genera, 1296 species.
(De Toni's *Sylloge Algarum*.)
5. Characeæ—2 families, 6 genera, 181 species.
(Engler and Prantl's *Pflanzenfamilien*).

Characeæ are separated from other *Chlorophyceæ* by a long interval, and present the highest degree of differentiation of parts known among Green Algæ. Attached to the bottom of pools by means of rhizoids, the thallus of *Characeæ* grows upwards by means of an apical cell, giving off whorled appendages at regular intervals. The appendages have a limited growth; but in connexion with each whorl there arise, singly or in pairs, branches which have the same unlimited growth as the main axis. There is thus a close approach to the external morphology of the higher plants. The streaming of the protoplasm, known elsewhere among *Chlorophyceæ*, is a conspicuous feature of the cells of *Characeæ*.

The *Chlorophyceæ* excel all other groups of Algæ in the magnitude and variety of form of the chlorophyll-bodies. In *Ulva* and *Mesocarpus* the chromatophore is a single plate, which in the latter genus places its edge towards the incident light; in *Spirogyra* they are spiral bands embedded in the primordial utricle; in *Zygnema* they are a pair of stellate masses, the rays of which branch peripherally; in *Œdogonium* they are longitudinally-disposed anastomosing bands; in Desmids plates with irregular margins; in *Cladophora* polyhedral plates; in *Vaucheria* minute elliptical bodies occurring in immense numbers. Embedded in the chromatophore, much in the same way as the nucleus is embedded in the cytoplasm, are the *pyrenoids*. Unknown in *Cyanophyceæ* and *Phæophyceæ*, known only in *Bangiaceæ* and *Nemalion* among *Rhodophyceæ*, they are of frequent occurrence among *Chlorophyceæ*, excepting *Characeæ*. Sometimes several pyrenoids occur in each chloroplast, as in *Mesocarpus* and *Spirogyra*; sometimes only an occasional chloroplast contains pyrenoid at all, as in *Cladophora*. The pyrenoid seems to be of proteid nature and gelatinous consistency, and to arise as a new formation or by division of pre-existing pyrenoids. When carbon-assimilation is active, starch-granules crowd upon the surface of the pyrenoid and completely obscure it from view.

Special provision for vegetative multiplication is not common among *Chlorophyceæ*. *Valonia* and *Caulerpa* among *Siphonales* detach portions of their thallus, which are capable of independent growth. In *Caulerpa* no other means of multiplication is as yet known. In *Characeæ* no fewer than four methods of vegetative reproduction have been described, and the facility with which buds and branches are in these cases detached has been adduced as an evidence of affinity with *Bryophyta*, which, as a class, are distinguished by their ready resort to vegetative reproduction.

With regard to true reproduction, which is characterized by the formation of special cells, the group *Euchlorophyceæ* is characterized by the production of zoospores; that is to say, cells capable of motility through the agency of cilia. Such ciliary motion is known in the adult condition of the cells of *Volvocaceæ*, but where this is not the case the reproductive cells are endowed with motility for a brief period. The zoospore is usually a pyriform mass of naked protoplasm, the beaked end of which where the cilia arise is devoid of colouring matter. A reddish-brown body, known as the eyespot, is usually situated near the limits of the hyaline portion, and in the protoplasm contractile vacuoles similar to those of lower animals have been occasionally detected. The movement of the zoospore is effected by the lashing of the cilia, and is in the direction of the beak, while the zoospore slowly rotates on its long axis at the same time. Usually two cilia are present; in *Botrydium* and *Hydrodictyon* only one is present; in certain species of *Cladophora* four; in *Dasycladus* a chaplet, and in *Œdogonium* a ring of many cilia. The so-called zoospore of *Vaucheria* is a cœnocyte covered over with paired cilia corresponding in position to nuclei lying below. In all other cases, zoospores are uninucleate bodies. Zoospores arise in cells of ordinary size and form termed zoosporangia. In unicellular forms (*Sphærella*) the thallus becomes transformed into a zoosporangium at the reproductive stage. In the zoosporangia of *Œdogonium*, *Tetraspora*, and *Coleochæte*, the contents become transformed into a single zoospore. In most cases repeated division seems to take place, and the final number is represented by some power of two. In cœnocytic forms the zoospores would seem to arise simultaneously, probably because many nuclei are already present. The escape of zoospores is effected by the degeneration of the sporangial wall (*Chætophora*), or by means of a pore (*Cladophora*), or a slit (*Pediastrum*), or a circular fracture (*Œdogonium*). Zoospores are of two kinds:—(1) Those which come to rest and germinate to form a new plant; these are asexual and are zoospores proper. (2) Those which are incapable of germination of themselves, but fuse with another cell, the product giving rise to a new individual; these are sexual and are zoogametes. When two similar zoogametes fuse, the process is conjugation, and the product a zygospore. Usually, however, only one of the fusing cells is a zoogamete, the other gamete being a much larger resting cell. In such a case the zoogamete is male, is called an antherozoid or spermatozoid, and arises in an antheridium; the larger gamete is an oosphere and arises in an oogonium. The fusion is now known as fertilization, and the product is an oospore. Reproduction by conjugation is also known as isogamy, by fertilization as oogamy. When zoospores come to rest, a new cell is formed and germination ensues at once. When zygospores and oospores are produced a new cell-wall is also formed, but a long period of rest ensues. All investigation goes to show that an essential part of sexual union is the fusion of the two nuclei concerned. It is interesting to know, on the authority of Oltmanns, that when the oosphere is forming in the oogonium of *Vaucheria*, there is a retrocession of all the included nuclei but one. That the antherozoid of *Vaucheria* contains a single nucleus had been inferred before.

From a comparison of those *Euchlorophyceæ* which have been most closely investigated, it appears probable that sexual reproductive cells have in the course of evolution arisen as the result of specialization among asexual reproductive cells, and that in turn oogamous reproduction has arisen as the result of differentiation of the two conjugating cells into the smaller male gamete and the larger female gamete. It would further appear that oogamous reproduction has arisen independently in each of the three main groups of *Euchlorophyceæ*, viz., *Protococcales*, *Siphonales*, and *Confervales*. Thus among *Volvocaceæ*, a family of *Protococcales*, while in some of the genera (*Chloraster*, *Sphondylomorum*), no sexual union has as yet been observed, in others (*Pandorina*, *Chlorogonium*, *Stephanosphæra*, *Sphærella*) conjugation of similar gametes takes place, in others still (*Phacotus*, *Eudorina*, *Volvox*) the union is of the nature of fertilization. No other family of *Protococcales* has advanced beyond the stage of isogamous reproduction. Again, among *Siphonales* only one family (*Vaucheriaceæ*) has reached the stage of oogamy, although an incipient heterogamy is said to occur in two other families (*Codiaceæ*, *Bryopsidaceæ*). Elsewhere among *Siphonales*, in those cases where reproductive cells are known, the reproduction is either isogamous or asexual. Among *Confervales* there is no family in which sexual reproduction—isogamy or oogamy—is not known to occur among some of the component species, and as many as four families (*Cylindrocapsaceæ*, *Sphæropleaceæ*, *Œdogoniaceæ*, *Coleochætaceæ*) are oogamous. On these, as well as other grounds, *Confervales* are regarded as having attained to the highest rank among *Euchlorophyceæ*. Although the phenomena attending isogamous and oogamous reproduction respectively are essentially the same in all cases, slight variations in both instances appear in different families, attributable doubtless to the independent origin of the process in different groups. Thus, although isogamy consists in typical cases of a union of naked motile gametes by a fusion which begins at the beaked ends, and results in the formation of an immotile spherical zygote surrounded by a cell-wall, in *Leptosira* it is noticeable that the fusion begins at the blunt end; in a species of *Chlamydomonas* the two gametes are each included in a cell-wall before fusion; and in many cases the zygote retains for some time its motility with the double number of cilia. Again, in oogamous reproduction, while in general only one oosphere is differentiated in the oogonium, in *Sphæroplea* several oospheres arise in each oogonium; and while the oospheres usually contract away from the oogonial wall, acquiring for themselves a new cell-wall after fertilization, in *Coleochæte* the oosphere remains throughout in contact with the oogonial wall. The oosphere is in all cases fertilized while still within the oogonium, the antherozoids being admitted by means of a pore. There is usually distinguishable upon the surface of the oosphere an area free from chlorophyll, known as the receptive spot, at which the fusion with the antherozoid takes place; and in many cases, before fertilization, a small mucilaginous mass has been observed to separate itself off from the oosphere at this point and to escape through the pore. In *Coleochæte* the oogonial wall is drawn out into a considerable tube, which is provided with an apical pore, and this tube has a somewhat similar appearance to the imperforate trichogyne of *Florideæ* to be hereafter described. In certain species of *Œdogonium* minute male plantlets, known as dwarf males, become attached to the female plant in the neighbourhood of the oogonia, thus facilitating fertilization. Indeed the genus *Œdogonium* exhibits a high degree of specialization in its reproductive system, considering that its thallus has not advanced beyond the stage of an unbranched filament.

Many *Euchlorophyceæ* are endowed with both asexual and sexual reproduction. Such are *Coleochæte*, *Œdogonium*, *Cylindrocapsa*, *Ulothrix*, *Vaucheria*, *Volvox*, &c. In others only the asexual method is yet known. When a species resorts to both methods, it is generally found that the asexual method prevails in the early part of the vegetative period, and the sexual towards the close of that period. This is in consonance with the facts already mentioned that zoospores germinate forthwith, and that the sexually-produced cell or zygote enters upon a period of rest. It is known that zoogametes, which usually conjugate, may, when conjugation fails, germinate directly (*Sphærella*). In rare cases the oosphere has been known to germinate without fertilization (*Œdogonium*, *Cylindrocapsa*). The germination of a zygospore or oospore is effected by the rupture of an outer cuticularized exosporium; then the cell may protrude an inner wall, the endosporium, and grow out into the new plant (*Vaucheria*), or the contents may break up into a first brood of zoospores. It is held that in *Coleochæte* a parenchyma results from the division of the oospore, from each cell of which a zoospore arises.

Reproduction is also effected among *Euchlorophyceæ* by means of aplanospores and akinetes. Aplanospores would seem to represent zoospores arrested in their development; without reaching the stage of motility, they germinate within the sporangium. Akinetes are ordinary thallus cells, which on account of their acquisition of a thick wall are capable of surviving unfavourable conditions. Both aplanospores and akinetes may germinate with or without the formation of zoospores at the initial stage.

Among *Conjugatæ* reproduction is effected solely by means of conjugation of what are literally aplanospores. Among those *Desmidiaceæ*, which live a free life, two plants become surrounded by a common mucilage, in which they lie either parallel (*Closterium*) or crosswise (*Cosmarium*). Gaps then appear in the apposed surfaces, usually at the isthmus; the entire protoplasts either pass out to melt into one another clear of the old walls, or partly pass out and fuse without complete detachment from the old walls. Among colonial *Desmidiaceæ*, the break-up of the filament is a preliminary to this conjugation; otherwise the process is the same. The zygospore becomes surrounded with its own wall, consisting finally of three layers, the outer of which is furnished with spicular prominences of various forms. In *Zygnemaceæ* there is no dissolution of the filaments, but the whole contents of one cell pass over by means of a conjugation-tube into the cavity of a cell of a neighbouring filament, where the zygospore is formed by the fusion of the two protoplasts. In these cases the activity of one of the gametes, and the passivity of the other, is regarded as evidence of incipient sex. In *Sirogonium* there is cell-division in the parent-cell prior to conjugation; and as two segments are cut off in the case of the active gamete, and only one in the case of the passive gamete, there is a corresponding difference of size, marking another step in the sexual differentiation. In *Zygogonium*, although no cell-division takes place, the gametes consist of a portion only of the contents of a cell, and this is regularly the case in *Mesocarpaceæ*, which occupy the highest grade among *Conjugatæ*. Some *Zygnemaceæ* and *Mesocarpaceæ* form either a short conjugating tube, or none at all, but the filaments approach each other by a knee-like bend, and the zygospore is formed at the point of contact, often being partially contained within the walls of the parent-cell. It would seem that in some cases the nuclei of the gametes remain distinct in the zygospore for a considerable time after conjugation. It is probable that in all cases nuclear fusion takes place sooner or later. In *Zygnemaceæ* and *Mesocarpaceæ* the zygospore, after a period of rest, germinates, to form a new filamentous colony; in *Desmidiaceæ* its contents divide on germination, and thus give rise to two or more Desmids. Gametes which fail to conjugate sometimes assume the appearance of zygospores and germinate in due course. They are known as azygospores.

The reproduction of *Characeæ* is characterized by a pronounced oogamy, the reproductive organs being the most highly differentiated among *Chlorophyceæ*. The antheridia and oogonia are formed at the nodes of the appendages. The oogonium, seated on a stalk cell, is surrounded by an investment consisting of five spirally-wound cells, from the projecting ends of which segments are cut off, constituting the so-called stigma. The oosphere is not differentiated within the wall of the oogonium, but certain cells known as *wendungszellen*, the significance of which has given rise to much speculation, are cut off from the basal portion of the parent-cell during its development. The antheridia are spherical, orange-coloured bodies of very complex structure. The antherozoid is a spirally-coiled thread of protoplasm, furnished at one end with a pair of cilia. It much more resembles the antherozoids of *Bryophyta* and certain *Pteridophyta* than any known among other Algæ. The fertilized egg charged with food reserves rests for a considerable period, surrounded by its cortex, the whole having assumed a reddish-brown colour. On germination it gives rise to a row of cells in which short (nodal) and long (internodal) cells alternate. From the first node arise rhizoids; from the second a lateral bud, which becomes the new plant. This peculiar product of germination, which intervenes between the oospore and the adult form, is the proembryo. It will be remembered that in *Musci* the asexual spore somewhat similarly gives rise to a protonema, from which the adult plant is produced as a lateral bud. The proembryonic branches of *Characeæ*, one of the means of vegetative reproduction already referred to, are so called because they repeat the characters of the proembryo.

Before leaving the *Chlorophyceæ*, it should be mentioned that the genus *Volvox* has been included by some zoologists (Bütschli, for example) among *Flagellata*; on the other hand, certain green *Flagellata*, such as *Euglena*, are included by some botanists (for example, van Tieghem) among unicellular plants. A similar uncertainty exists with reference to certain groups of *Phæophyceæ*, and the matter will thus arise again.

3. PHÆOPHYCEÆ.[1]—The *Phæophyceæ* are distinguished by the possession of a brown colouring matter, phycophæin, in addition to chlorophyll. They consist of the following groups:—*Fucaceæ*, *Phæosporeæ*, *Dictyotaceæ*, *Cryptomonadaceæ*, *Peridiniaceæ*, and *Diatomaceæ*. Of these the first three include multicellular plants, some of them of great size; the last three are unicellular organisms, with little in common with the rest excepting the possession of a brown colouring matter. *Fucaceæ* and *Phæosporeæ* are doubtless closely allied, and to these *Dictyotaceæ* may be joined, though the relationship is less close. They constitute the *Euphæophyceæ*, and will be dealt with in the first place.

Euphæophyceæ are almost exclusively marine, growing on rocks and stones on the coast, or epiphytic upon other Algæ. In tidal seas they range from the limits of high water to some distance beyond the low-water line. On the British coasts zones are observable in passing from high- to low-water mark, characterized by the prevalence of different species, thus:—*Pelvetia canaliculata*, *Fucus platycarpus*, *Fucus vesiculosus*, *Ascophyllum nodosum*, *Fucus serratus*, *Laminaria digitata*. Some species are minute filamentous plants, requiring the microscope for their detection; others, like *Lessonia*, are of considerable bulk; or, like *Macrocystis*, of enormous length. In *Fucaceæ*, *Dictyotaceæ*, and *Laminariaceæ* and *Sphacelariaceæ*, among *Phæosporeæ*, the thallus consists of a true parenchyma; elsewhere it consists of free filaments, or filaments so compacted together, as in *Cutleriaceæ* and *Desmarestiaceæ*, as to form a false parenchyma. In *Fucaceæ* and *Laminariaceæ* the inner tissue is differentiated into a conducting system. In *Laminariaceæ* the inflation of the ends of conducting cells gives rise to the so-called trumpet-hyphæ. In *Nereocystis* and *Macrocystis* a zone of tubes occurs, which present the appearance of sieve-tubes even to the eventual obliteration of the perforations by a callus. While there is a general tendency in the group to mucilaginous degeneration of the cell-wall, in *Laminaria digitata* there are also glands secreting a plentiful mucilage. Secondary growth in thickness is effected by the tangential division of superficial cells. The most fundamental external differentiation is into holdfast and shoot. In *Laminariaceæ* secondary cylindrical props arise obliquely from the base of the thallus. In epiphytic forms the rhizoids of the epiphyte often penetrate into the tissue of the host, and certain epiphytes are not known to occur excepting in connexion with a certain host; but to what extent, if any, there is a partial parasitism in these cases has not been ascertained. In filamentous forms there is a differentiation into branches of limited and branches of unlimited growth (*Sphacelaria*). In *Laminariaceæ* there is a distinction of stipe and blade. The blade is centrally-ribbed in *Alaria* and laterally-ribbed in *Macrocystis*. It is among the *Sargassaceæ* that the greatest amount of external differentiation, rivalling that of the higher leafy plants, is reached. A characteristic feature of the more massive species is the occurrence of air-vesicles in their tissues. In *Fucus vesiculosus* they arise in lateral pairs; in *Ascophyllum* they are single and median; in *Macrocystis* one vesicle arises at the base of each thallus segment; in *Sargassum* and *Halidrys* the vesicles arise on special branches. They serve to buoy up the plant when attached to the sea-bottom, and thus light is admitted into the forest-like growths of the gregarious species. When such plants are detached they are enabled to float for great distances, and the great Sargasso Sea of the North Atlantic Ocean is probably only renewed by the constant addition of plants detached from the shores of the Caribbean Sea and Gulf of Mexico.

Growth in length is effected in a variety of ways. In *Dictyota*, *Sphacelariaceæ*, and *Fucaceæ* there is a definite apical cell. In the first it is a biconvex lens, from which segments are continually cut off parallel to the posterior surface; and in the second an elongated dome, from which segments are cut off by a transverse wall. While, however, in *Dictyota* the product of the subsequent division in the segment enlarges with each subdivision, the divisions in the cylindrical segment of *Sphacelariaceæ* are such that the whole product after subdivision, however many cells it may consist of, does not exceed in bulk the segment as cut off from the apical cell. In *Dictyotaceæ* the apical cell occasionally divides

---

[1] Phæophyceæ include:—

1. *Cyclosporinæ* (*Fucaceæ*)—4 families, 32 genera, 347 species.
2. *Tetrasporinæ* (*Dictyotaceæ*)—1 family, 17 genera, 130 species.
3. *Phæozoosporineæ* (*Phæosporeæ*)—24 families, 143 genera, 571 species.

(De Toni's *Sylloge Algarum.*)

4. *Peridiniales*—3 families, 32 genera, 167 species.
5. *Cryptomonadaceæ* (including *Chrysomonadaceæ*)—2 families, 28 genera, 50-60 species.
6. *Bacillariales* (*Diatomaceæ*)—about 150 genera, and 5000 species, fossil and recent.

(Engler and Prantl's *Pflanzenfamilien.*)

longitudinally, and thus the dichotomous branching is provided for. In some *Sphacelariaceæ* branches may appear at their inception as lateral protuberances of the apical cell itself. In *Fucaceæ* an apical cell is situate at the surface of the thallus in a slit-like depression at the apex. From this cell segments are cut off in three or four lateral oblique planes.

A peculiar manner of growth in length is that to which the term trichothallic has been applied. It may readily be observed that in the hair-like branches of *Ectocarpaceæ*, the point at which most rapid division occurs is situate near the base of the hair. In *Desmarestia* and *Arthrocladia*, for example, it is found that the thallus ends in a tuft of such hairs, each of them growing by means of an intercalated growing point. In these cases, however, the portions of the hairs behind the growing region become agglutinated together into a solid cylindrical pseudo-parenchymatous axis. In *Cutleria* the laminated thallus is formed in the same way. The intercalated growing region of *Laminaria* affords an example of another variety of growth in *Phæophyceæ*. While the laminated portion of the thallus is being gradually worn off in our latitudes during the autumnal storms, a vigorous new growth appears at the junction of the stipe and the blade, as the result of which a new piece is added to the stipe and the lamina entirely renovated.

Both asexual and sexual reproduction occur among *Euphæophyceæ*. *Fucaceæ* are marked by an entire absence of the asexual method. The sexual organs—oogonia and antheridia—are borne on special portions of the thallus in cavities known as conceptacles. Both organs may occur in one conceptacle, as in *Pelvetia*, or each may be confined to one conceptacle or even one plant, as in *Fucus vesiculosus*. The oogonia arise on a stalk cell from the lining layer of the cavity, the contents dividing to form eight oospheres as in *Fucus*, four as in *Ascophyllum*, two as in *Pelvetia*, or one only as in *Halidrys*. It would seem that eight nuclei primarily arise in all *Fucaceæ*, and that a number corresponding to the number of oospheres subsequently formed is reserved, the rest being discharged to the periphery, where they may be detected at a late stage. On the maturation of the oospheres the outer layer of the oogonial wall ruptures, and the oospheres, still surrounded by a middle and inner layer, pass out through the mouth of the conceptacle. Then usually these layers successively give way, and the spherical naked oospheres float free in the water. The antheridia, which arise in the conceptacular cavity as special cells of branched filaments, are similarly discharged whole, the antherozoids only escaping when the antheridia are clear of the conceptacle. The antherozoids are attracted to the oospheres, round each of which they swarm in great numbers. Suddenly the attraction ceases, and the oosphere is fertilized, probably at that moment, by the entry of a single antherozoid into the substance of the oosphere; a cell-wall is formed thereupon, in some cases in so short an interval as five minutes. Remarkable changes of size and outline of the oosphere have recently been described as accompanying fertilization in *Halidrys*. Probably the act of fertilization in plants has nowhere been observed in such detail as in *Fucaceæ*. *Dictyotaceæ* resemble *Fucaceæ* in their pronounced oogamy. They differ, however, in being also asexually reproduced. The asexual cells are immotile spores arising in fours in sporangia from superficial cells of the thallus. In *Dictyota* the oospheres arise singly in oogonia, crowded together in sori on the surface of the female plant. The antheridia have a similar origin and grouping on the male plant. Until the recent discovery by Williams of motility, by means of a single cilium, of the antherozoids of *Dictyota* and *Taonia*, they were believed to be immotile bodies, like the male cells of red seaweeds. In *Dictyota* the unfertilized oosphere is found to be capable of undergoing a limited number of divisions, but the body thus formed appears to atrophy sooner or later.

Of the small family of the *Tilopteridaceæ* our knowledge is as yet inadequate, but they probably present the only case of pronounced oogamy among *Phæosporeæ*. They are filamentous forms, exhibiting, however, a tendency to division in more than one plane, even in the vegetative parts. The discovery by Brebner of the specific identity of *Haplospora globosa* and *Scaphospora speciosa* marks an important step in the advance of our knowledge of the group. Three kinds of reproductive organs are known: first, sporangia, which each give rise to a single tetra-, or multinucleate non-motile, probably asexual spore; second, plurilocular sporangia, which are probably antheridia, generating antherozoids; and third, sporangia, which are probably oogonia, giving rise to single uninucleate non-motile oospheres. No process of fertilization has as yet been observed.

The *Cutleriaceæ* exhibit a heterogamy in which the female sexual cell is not highly specialized, as it is in the groups already described. From each loculus of a plurilocular sporangium there is set free an oosphere, which, being furnished with a pair of cilia, swarms for a time. In similar organs on separate plants the much smaller antherozoids arise. Fertilization has been observed at Naples; but it apparently depends on climatic conditions, as at Plymouth the oospheres have been observed to germinate parthenogenetically. The asexual organs in the case of *Cutleria multifida* arise on a crustaceous form, *Aglaozonia reptans*, formerly considered to be a distinct species. They are unilocular, each producing a small number of zoospores.

The possession of two kinds of reproductive organs, unilocular and plurilocular sporangia, is general among the rest of the *Phæosporeæ*. Bornet, however, called attention in 1871 to the fact that two kinds of plurilocular sporangia occurred in certain species of the genus *Ectocarpus*—somewhat transparent organs of an orange tint producing small zoospores, and also more opaque organs of a darker colour producing relatively larger zoospores. On the discovery of another such species by Buffham, Batters in 1892 separated the three species, *Ectocarpus secundus*, *E. fenestratus*, *E. Lebelii*, together with the new species, into a genus, *Giffordia*, characterized by the possession of two kinds of plurilocular sporangia. The suspicion that a distinction of sex accompanied this difference of structure has been justified by the discovery by Sauvageau of undoubted fertilization in *Giffordia secunda* and *G. fenestrata*. The conjugation of similar gametes, arising from distinct plurilocular sporangia, was observed by Berthold in *Ectocarpus siliculosus* and *Scytosiphon lomentarius* in 1880; and these observations have been recently confirmed in the case of the former species by Sauvageau, and in the case of the latter by Kuckuck. In these cases, however, the potential gametes may, failing conjugation, germinate directly, like the zoospores derived from unilocular sporangia. The assertion of Areschoug that conjugation occurs among zoospores derived from unilocular sporangia, in the case of *Dictyosiphon hippuroides*, is no doubt to be ascribed to error of observation. It would thus seem that the explanation of the existence of two kinds of sporangia, unilocular and plurilocular, among *Phæosporeæ*, lies in the fact that unilocular sporangia are for asexual reproduction, and that plurilocular sporangia are gametangia—potential or real. It must, however, be remembered that so important a generalization is as yet supported upon a somewhat narrow base of observation. Moreover, for the important family of the *Laminariaceæ* only unilocular sporangia are known to occur; and for many species of other families, only one or other kind, and in some cases neither kind, has hitherto been observed. The four species—*Ectocarpus siliculosus*, *Giffordia secunda*, *Cutleria multifida*, and *Haplospora globosa*—may be taken to represent, within the *Phæosporeæ*, successive steps in the advance from isogamy to oogamy.

The *Peridiniaceæ* have been included among *Flagellata* under the title of *Dinoflagellata*. The majority of the species belong to the sea, but many are found in freshwater. The thallus is somewhat spherical and unicellular, exhibiting a distinction between anterior and posterior extremities, and dorsal and ventral surfaces. The wall consists of a basis of cellulose, and in some cases readily breaks up into a definite number of plates, fitting into another like the plates of the carapace of a tortoise; it is, moreover, often finely sculptured or coarsely ridged and flanged. Two grooves are a constant feature of the family, one running transversely and another longitudinally. In these grooves lie two cilia, attached at the point of meeting on the dorsal surface. The protoplast is uninucleate and vacuolate, and contains chromatophores of a brownish colour. It is not clear that the brown colouring matter which is added to chlorophyll is identical with phycophæin; two varieties of it have been termed phycopyrrin and peridinine. Certain species, such as *Gymnodinium spirale*, are colourless and therefore saprophytic in their method of nutrition. Multiplication takes place in some cases by the endogenous formation of zoospores, the organism having come to rest; in others by longitudinal division, when the organism is still motile. No method of sexual reproduction is known with certainty.

The *Cryptomonadaceæ* also are unicellular, and live free or in colonies. Each cell contains a flattened chromatophore of a brown or yellow colour. *Hydrurus* forms a branched gelatinous colony attached to stones in mountain streams. *Chromophyton* form an eight-celled colony. Both plants multiply solely by means of zoospores. The *Cryptomonadeæ* and *Chromulineæ* are motile through the greater part of their life. *Cryptomonas*, when dividing in a mucilage after encystment, recalls the condition in *Glœocystis*. In *Synura* and *Chromulina* the cells form a spherical motile colony, recalling *Volvocaceæ*. *Chromulina* is uniciliate and is contained in a hyaline capsule. Like the *Peridiniaceæ*, the *Cryptomonadaceæ* have been included among *Flagellata*. They have no close affinity with *Euphæophyceæ*. Such colonial forms as *Hydrurus* and *Phæocystis* are supposed, however, to indicate a stage in the passage to the multicellular condition.

Diatomaceæ have long been recognized as plants. Together with *Peridiniaceæ* they constitute the bulk of marine plankton, and thus play an important part in the support of marine animal life. They exhibit striking adaptations in these circumstances to the floating habit. (See DIATOMACEÆ, ninth ed.)

4.—RHODOPHYCEÆ, or FLORIDEÆ.[1]—The members of this group are characterized by the possession of a red colouring-matter, phycoerythrin, in addition to chlorophyll. There is, however, a considerable amount of difference in the shades of red which mark different species. The brightest belongs to those species which grow near low-water mark, or under the shade of larger Algæ at higher levels; species which grow near high-water mark are usually of so dark a hue that they are easily mistaken for brown seaweeds. *Rhodophyceæ* are mostly marine, but not exclusively so. *Thorea*, *Lemanea*, *Tuomeya*, *Stenocladia*, *Batrachospermum*, *Balbiania*, are genera belonging entirely to fresh water; and *Bangia*, *Chantransia*, *Caloglossa*, *Bostrychia*, and *Delesseria* contain each one or more fresh-water species. Most of the larger species of marine *Rhodophyceæ* are attached by means of a disc to rocks, stones, or shells. Many are epiphytic on other Algæ, more especially the larger *Phæophyceæ* and *Rhodophyceæ*. As in the case of epiphytic brown seaweeds, the rhizoids of the epiphyte often penetrate the substance of the supporting Alga. Some Red Algæ find a home in the gelatinous substance of *Flustra*, *Alcyonidium*, and other polyzoa, only emerging for the formation of the reproductive organs. Some are perforating Algæ and burrow into the substance of molluscan shells, in company with certain Green and Blue-green Algæ. Some species belonging to the families *Squamariaceæ* and *Corallinaceæ* grow attached through their whole length and breadth, and are often encrusted with lime. The forms which grow away from the substratum vary greatly in external configuration. In point of size the largest cannot rival the larger Brown Algæ, while the majority require the aid of the microscope for their investigation.

No unicellular *Rhodophyceæ* are known, although a flagellate organism, *Rhodomonas*, has recently been described as possessed of the same red colouring-matter. If the sub-group, *Bangiaceæ*, be excluded, they may be said to consist exclusively of branched filaments. Growth in these cases takes place by means of an apical cell, from which successive segments are cut off by means of a transverse wall. The segment so cut off does not usually divide again by means of a transverse wall, nor indeed by a longitudinal wall which passes through the organic axis of the cell. New cells may be cut off laterally, which become the apical cells of branches. When the new cells grow no further, but constitute a palisading round the central cell covering its whole length, the condition is reached which characterizes the species of *Polysiphonia*, the "siphons" of which may be regarded as one-celled branches. To the law that no subsequent transverse division takes place in segments cut off from the apical cell, there seem to be two exceptions: first, the calcareous genus *Corallina*, in the pliable joints of which intercalated division occurs; and, second, the *Nitophylleæ*, in which, moreover, median longitudinal division of axial cells is said to occur. Like the Fungi, therefore, the Red Algæ consist for the most part of branched filaments, even where the thallus appears massive to the eye, and, as in the case of Fungi, this fact is not inconsistent with a great variety of external morphology. In the great majority the thallus is obviously filamentous, as in some species of *Callithamnion*. In other species of that genus an apparent cortication arises by the downward growth of rhizoids, which are retained within the gelatinous wall of the axial cells. In *Batrachospermum* the whole system of branches are retained within a diffluent gelatinous substance derived from the outer layers of the cell-walls. In other cases the mucilage is denser and the branches more closely compacted (*Helminthora*). In such cases as *Lemanea*, the terminal cells of the lateral branches form a superficial layer which has all the appearance of a parenchyma when viewed from the surface. In *Champia* and allied genera, the cylindrical axis is due not to the derivatives of one axial filament, but of several, the growth of which is co-ordinated to form a septated tube. The branching of the thallus, which meets the eye in all these cases, is due to the unlimited growth of a few branches. When such a lateral branch overtops the main axis whose growth has become limited, as in *Plocamium* and *Dasya*, a sympodium is formed. For the most part the branching is monopodial. Besides the differentiation into holdfast and shoot, and into branches of limited and branches of unlimited growth, there appear superficial structures of the nature of hairs. These are for the most part long, thin-walled, unicellular, and colourless, and arise from the outer cells of the pseudo-cortex, or from the terminal cells of branches when the filaments are free. Among *Rhodomelaceæ*, hair-like structures of a higher order are known. These arise from the axial cell, and are multicellular and branched. They soon fall off, and it is from the persistent basal cell that the branches of unlimited growth arise. Upon them also the reproductive organs arise in this family. It is not surprising, therefore, that they have been regarded as the rudiments of leaves. In *Iridæa* the thallus is an entire lamina; in *Callophyllis* a lobed lamina; in *Delesseria* it is provided with midrib and veins, simulating the appearance of a leaf of the higher plants; in *Constantinea* the axis remains cylindrical, and the lateral branches assume the form of leaves. In the compact thalli a secondary development often takes place by the growth of rhizoid-like internal filaments. They present a hypha-like appearance, running longitudinally for considerable distances. It is not difficult in such compact species to distinguish between superficial cells, whose chief function is assimilation, subjacent cells charged with reserve material, and a core of tissue engaged in the convection of elaborated material from part to part.

An interesting feature of the minute anatomy of *Eufloridieæ*, as the Red Algæ, exclusive of the *Bangiaceæ*, have been termed, is the existence of the so-called *Floridean pit*. When a cell divides it is found that there remains in the middle of the new wall a single large circular pit, which persists throughout the life of the cells, becoming more and more conspicuous with the progress of the thickening of the wall. These pits serve to indicate the genetic relationship of adjacent cells, when they form a compact pseudo-parenchyma, notwithstanding the fact that somewhat smaller secondary pits appear later between any contiguous cells. Protoplasmic continuity has been observed in the delicate membrane closing the pit.

Vegetative multiplication occurs only sparingly in *Rhodophyceæ*. *Melobesia callithamnioides* gives rise to multicellular propagula; *Griffithsia corallina* is said to give rise to new individuals, by detaching portions of the thallus from the base of which new attachment organs have already arisen. The spores of *Monospora* are by some regarded as unicellular propagula. Reproduction is both asexual and sexual. It is noteworthy that although all the members of the group are aquatic no zoospores are produced, a negative character common to them and the Blue-green Algæ. As a rule the asexual cells and the male and female sexual cells arise upon different plants, so that the species may be said to be trioecious. Numerous exceptions, however, occur. Thus in *Lemaneaceæ* asexual spores are unknown; in *Batrachospermum*, *Bonnemaisonia*, and *Polysiphonia byssoides* both kinds of sexual cells appear on the same plant; and in some cases the asexual cells may occur in conjunction with either the male or female sexual cells. The asexual cells are termed tetraspores on account of the usual occurrence of four in each sporangium. What may be termed monospores, bispores, and octospores, however, are not unknown. The sporangia may be terminal or intercalated. When they are confined to special branches, such branches are spoken of as stichidia. The tetraspores may arise by the simultaneous division of the contents of a sporangium, when they are arranged tetrahedrally, or they may arise by two successive divisions, in which case the arrangement may be zonate when the spores are in a row, or cruciate when the second divisions are at right angles to the first, or tetrahedral when the second divisions are at right angles to the first and also to one another. Tetraspores are at first naked, but soon acquire a cell-wall and germinate without a period of rest. The male sexual cells are produced singly in the terminal cells of branches. They are spoken of as spermatia. Great numbers of antheridia are usually crowded together, when the part is distinguishable by the absence of the usual red colour. In *Polysiphonia* they cover the joints of the so-called leaves; in *Chondria* they arise on flattened discs; in the more massive forms they arise in patches on the ordinary surface; in a few cases (*Gracilaria*, *Corallina*, *Galaxaura*) they line the walls of conceptacle-like depressions. The female sexual cell is represented by the contents of a cell which is terminal on ordinary or specialized branches. This is the carpogonium; it consists of a ventral portion which contains a nucleus, but in which no oosphere is differentiated, and an elongated tubular portion known as the trichogyne, into which the cytoplasm extends. Fertilization is effected by the passive convection of a spermatium from the antheridium to the trichogyne, to which it adheres, and to which it passes over its nucleus through an open communication set up at the point of contact. The nucleus then passes down the trichogyne and fuses with that of the egg. This fusion has been observed by Wille in *Nemalion multifidum*, and by Schmidle in *Batrachospermum*. It is singular that in the last-named species two nuclei occur regularly in the spermatium. The ventral portion of the carpogonium may be imbedded deep in the thallus in the massive species; the trichogyne, however, always reaches the surface. The first effect of fertilization is the occlusion of the trichogyne from the fertilized carpogonium. The subsequent course of development is characteristic of the *Florideæ*. The carpogonium germinates forthwith, drawing its nourishment almost wholly from the parent plant. The ultimate product in all cases is a number of carpospores, but before this stage

---

[1] These include:—

1. *Bangiaceæ*—4 families, 9 genera, 58 species.
2. *Nemalioninæ*—4 families, 33 genera, 343 species.
3. *Gigartininæ*—3 families, 54 genera, 409 species.
4. *Rhodymeninæ*—4 families, 92 genera, 602 species.

(De Toni's *Sylloge Algarum*.)

is reached the development is different in different sub-groups. In *Batrachospermum* filaments arise from the carpogonium on all sides; in *Chantransia* and *Scinaia* on one side only; in *Helminthora* the filaments are enclosed in a dense mucilage; in *Nemalion*, prior to the formation of the filaments, a sterile segment is cut off below. In all these cases, however, the end-cells of the filaments each give rise to a carpospore, and the aggregate of such sporiferous filaments is a cystocarp. Again, in the family of the *Gelidiaceæ*, the single filament arising from the carpogonium grows back into the tissue and preys upon the cells of the axis and larger branches, after which the end-cells give rise to carpospores and a diffused cystocarp is formed. In the whole group of the *Cryptonemiales* the parasitism becomes more marked still. The filaments arising from the carpogonia grow into long thin tubes, which fuse with special cells rich in protoplasm contents; and from these points issue isolated tufts of sporogenous filaments, several of which may form the product of one fertilized female cell. In *Naccaria*, one of the *Gelidiaceæ*, it is observable that the ooblastema filament, as the tube arising from the fertilized carpogonium has been called, fuses completely with a cell contiguous to the carpogonium before giving rise to the foraging filaments already referred to. This is also the case among *Cryptonemiales*. In a whole series of Red Algæ, the existence of a highly-specialized auxiliary cell in the neighbourhood of the carpogonium is a characteristic feature. In the *Gigartinales* it is already differentiated previous to fertilization; in *Rhodymeniales* it arises subsequent to fertilization. In the *Gigartinales*, the filaments which arise from the auxiliary cell may spread and give rise to isolated tufts of sporogenous filaments, as in the *Cryptonemiales*. In the *Rhodymeniales* a single tuft arises directly from the auxiliary cell. The carpospores are in all cases bright red naked masses of protoplasm when first discharged. They soon acquire a cell-wall, and germinate without a period of rest. When the cystocarps or segments of cystocarps are formed in the substance of a thallus, the site is marked merely by a swelling of the substance. When the cystocarp is produced externally, it may form a berry-like mass without an envelope, in which case it is known as a favella. In *Rhodomelaceæ* there is a special urn-shaped envelope surrounding the sporogenous filaments. This is a ceramidium.

The attachment of the cell of an ooblastema filament to a cell of the thallus may be effected by means of a minute pore, or the two cells may fuse their contents into one protoplasmic mass. In the latter case, and especially where the union is with a special auxiliary cell, it is of importance to know what happens to the nuclei of the fusing cells. Schmitz was of opinion that in the cases of open union there occurred a fusion of nuclei similar to that which occurs in the sexual union of two cells. He founded his generalization to a large extent upon the observation that in *Glœosiphonia capillaris* two cells completely fuse, and that only one nucleus can be detected in the fused mass. Oltmanns has recently reinvestigated the phenomena in this plant, among others, and has shown that the nucleus of the cell which is being preyed upon recedes to the wall and gradually atrophies. The nucleus of the ooblastema filament dominates the mass, and from it all the nuclei of the carpospores are thus derived. There thus seems to be no justification for believing, as Schmitz taught, that a second sexual act occurs in the life-cycle of these *Florideæ*.

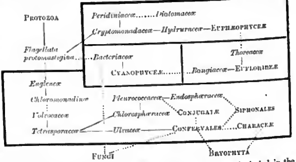
The *Bangiales* are a relatively small group of Red Algæ, to which much of the description now given does not apply. Structurally they are either a plate of cells, as in *Porphyra*, or filaments, as in *Bangia*. There is no exclusive apical growth, and the cells divide in all directions. The characteristic pit is also absent. Sexual and asexual reproduction prevail. The male cell is a spermatium, but the female cell bears no such receptive trichogyne as occurs in other *Rhodophyceæ*. After fertilization the equivalent of the oospore divides directly to form a group of carpospores. There is thus a certain resemblance to *Eufloridæ*, but sufficient difference to necessitate their being grouped apart. Fertilization by means of non-motile spermatia and a trichogyne are known among the *Fungi* in the families *Collemaceæ* and *Laboulbeniaceæ*.

Limits of the Algæ.

After this survey of the four groups comprised under Algæ, it is easier to indicate the variations in the limits of the class as defined by different authorities. To consider the *Cyanophyceæ* first, either the marked contrast in the method of nutrition of the generally colourless *Bacteriaceæ* to that of the blue-green *Cyanophyceæ* is regarded as sufficient ground for excluding *Bacteriaceæ* from Algæ altogether, notwithstanding their acknowledged morphological affinity with *Cyanophyceæ*, or, in recognition of the incongruity of effecting such a separation, the whole group of the *Schizophyta*—that is to say, the *Cyanophyceæ* in the narrow sense, together with *Bacteriaceæ*, is included or excluded together. Again, while *Conjugatæ* may be shut out from *Chlorophyceæ* as an independent group co-ordinate with them in rank, the *Characeæ* constitute so aberrant a group that it has even been proposed to raise them as *Charophyta* to the dignity of a main division co-ordinate with *Thallophyta*. Similarly, while *Diatomaceæ* may be excluded from among *Phæophyceæ*, though retained among Algæ, the *Cryptomonadaceæ* and *Peridiniaceæ*, like *Euglena* and other *Chlorophyceæ*, may be excluded from *Thallophyta* and ranged among the Flagellate *Protozoa*. (See PROTOZOA.) It is doubtful, however, whether the conventional distinction between plants and animals will continue to be urged; and the suggestion of Haeckel that a class *Protista* should be established to receive the forms exhibiting both animal and plant affinities has much to recommend it on phylogenetic grounds. To adopt a figure, it is probable that the sources from which the two streams of life—animal and vegetable—spring may not be separable by a well-defined watershed at all, but consist of a great level upland, in which the waterways anastomose. Finally, while *Chlorophyceæ* and *Phæophyceæ* exhibit important affinities, the *Rhodophyceæ* are so distinct that the term Algæ cannot be made to include them, except when used in its widest sense.

Phylogeny.

It has been well said that the attempt to classify plants according to their natural affinities is an attempt to construct for them the genealogical tree by which their relationships can be traced. Algæ are, however, so heterogeneous a class, of which the constituent groups are so inadequately known, that it is at present futile to endeavour thus to exhibit their pedigree. A synoptical representation of the present state of knowledge would be expressed by a network rather than by a tree. The following table is an adaptation of a scheme devised by Klebs, and indicates the inter-relationships of the various constituent groups. The area included in the thick boundary line represents Algæ in the widest sense in which the term is used, and the four included areas the four main subdivisions. A continuous line indicates a close affinity, and a dotted line a doubtful relationship.



Alternation of generations.

In comparing Algæ with the great Archegoniate series which has doubtless sprung from them, it is natural to inquire to what extent, if any, they present evidence of the existence of the marked alternation of generations which dominates the life-history of the higher plants. Turning first to the *Rhodophyceæ*, both on account of the high place which they occupy among Algæ and also the remarkable uniformity in their reproductive processes, it is clear that, as is the case among *Archegoniatæ*, the product of the sexual act never germinates directly into a plant which gives rise to the sexual organs. Even among *Bangiaceæ* the carpospores arise from the fertilized cell by division, while in all other *Rhodophyceæ* the oospore, as it may be called, gives rise to a filamentous structure, varying greatly in its dimensions, epiphytic, and to a large extent parasitic upon the egg-bearing parent plant, and in the end giving rise to carpospores in the terminal cells of certain branches. There is here obviously a certain parallelism with the case of *Bryophyta*, where the sporogonium arising from the oospore is epiphytic and partially parasitic upon the female plant, and always culminates in the production of spores. Yet even *Riccia*, with its rudimentary sporogonium, has so simple a corresponding stage as *Bangia*, for, while there is some amount of sterile tissue in *Riccia*, in *Bangia* the oospore completely divides to form carpospores. Excluding *Bangiaceæ*, however, from consideration, the *Eufloridеæ* present in the product of the development of the oospore like *Bryophyta* a structure partly sterile and partly fertile. There is, nevertheless, this important difference between the two cases. While the spore of *Bryophyta* on germination gives rise to the sexual plant, the carpospore of the Alga may give rise on germination to a plant bearing a second sort of asexual cells, viz., the tetraspores, and the sexual plant may only be reached after a series of such plants have been successively generated. It is possible, however, that the tetraspore formation should be regarded as comparable with the prolific vegetative reproduction of *Bryophyta*, and in favour of this view there is the fact that the tetraspores originate on the thallus in a different way from carpospores with which the spores of *Bryophyta* are in the first place to be compared; moreover, in certain *Nemalionales* the production of tetraspores does not occur, and the difficulty referred to does not arise in such cases. Altogether, it is difficult to resist the conclusion that *Florideæ* present in a modified form the same fundamental phenomenon of alternation of generations as prevails in the higher plants. Among *Phæophyceæ* it is well known that the oospore of *Fucaceæ* germinates directly into the sexual plant, and there is thus only one generation. Moreover, it is known that the reduction in the number of chromosomes which occurs at the initiation of the gametophyte generation in *Pteridophyta* occurs in the culminating stage of *Fucus*, where the oogonium is separated from the stalk-cell, so that, unless it be contended that the *Fucus* is really a sporophyte which does not produce spores, and that the gametophyte is represented merely by the oogonium and antheridium, there is no semblance of alternation of generation in this case. The only case among *Phæophyceæ* which has been considered to point to the existence of such a phenomenon is *Cutleria*. Here the asexual cells are borne upon the so-called *Aglaozonia reptans* and the sexual cells upon the plants known as *Cutleria*. The spores of the *Aglaozonia* form are known to give rise to sexual plants, and the oospore of *Cutleria* has been observed to grow into rudimentary *Aglaozonia*. It is probable, however, that there is nothing more here than strongly contrasted growth-forms. Among *Chlorophyceæ*, it is often the case that the oospore on germination divides up directly to form a brood of zoospores. In *Coleochæte*, this seems to be preceded by the formation of a minute parenchymatous mass, in each cell of which a zoospore is produced. In *Sphæroplea*, it is only at this stage that zoospores are formed at all; but in most cases, such as *Œdogonium*, *Ulothrix*, *Coleochæte*, similar zoospores are produced again and again upon the thallus, and the product of the oospore may be regarded as merely a first brood of a series. It has been held by some, however, that the first brood corresponds to the sporophyte generation of the higher plants, and that the rest of the cycle is the gametophyte generation. Were the case of *Sphæroplea* to stand alone, the phenomenon might perhaps be regarded as an alternation of generations, but still only comparable with the case of *Bangia*, and not the case of the *Florideæ*. But it is difficult to apply such a term at all to those cases in which there intervene between the oospore and the next sexual stage a series of generations, the zoospores of which are all precisely similar.

Polymorphism.

The difficulty of tracing the relationships of Algæ is largely due to the inadequacy of our knowledge of the conditions under which they pass through the critical stages of their life-cycle. Of the thousands of species which have been distinguished, relatively few have been traced from spore to spore, as the flowering plants have been observed from seed to seed. The aquatic habit of most of the species and the minute size of many of them are difficulties which do not exist in the case of most seed-plants. From the analogy of the higher plants observers have justly argued that when they have seen and marked the characters of the reproductive organs they have found the plant at the stage when it exhibits its most noteworthy features, and they have named and classified the species in accordance with these observations. While even in such cases it is obvious that interesting stages in the life of the plant may escape notice altogether, in the cases of those plants the reproduction of which is unknown, and which have been named and placed on the analogy of the vegetative parts alone, there is considerable danger that a plant may be named as a distinct species which is only a stage in the life of another distinct and perhaps already known species. To take an example, *Lemanea* and *Batrachospermum* are *Florideæ* which bear densely-whorled branches, but which, on the germination of the carpospore, give rise to a laxly-filamentous, somewhat irregularly branched plant, from which the ordinary sexual plants arise at a later stage. This filamentous structure has been attributed to the genus *Chantransia*, which it greatly resembles, especially when, as is said to be the case in *Batrachospermum*, it bears similar monospores. The true *Chantransia*, however, bears its own sexual organs as well as monospores. To the specific identity of *Haplospora globosa* and *Scaphospora speciosa*, and of *Cutleria multifida* and *Aglaozonia reptans*, reference has already been made. Again, many Green Algæ — some unicellular, like *Sphærella* and *Chlamydomonas;* some colonial forms, like *Volvox* and *Hormotila;* some even filamentous forms, like *Ulothrix* and *Stigeoclonium*—are known to pass into a condition resembling that of a *Palmella*, and might escape identification on this account.

It is, on the other hand, a danger in the opposite sense to conclude that all *Chantransia* species are stages in the life-cycle of other plants, and, similarly, that all irregular colonial forms, like *Palmella*, represent phases in the life of other Green Algæ. Long ago, Kützing went so far as to express the belief that the lower Algæ were all capable of transformations into higher forms, even into moss-protonemata. Later writers have also thought that in all four groups of Algæ transformations of a most far-reaching character occur. Thus Borzi finds that *Protoderma viride* passes through a series of changes so varied that at different times it presents the characters of twelve different genera. Chodat does not find so general a polymorphism, but nevertheless holds that *Raphidium* passes through stages represented by *Protococcus*, *Characium*, *Dactylococcus*, and *Sciadium*. Klebs has, however, recently canvassed the conclusions of both these investigators; and as the result of his own observations declares that Algæ, so far from being as polymorphic as they have been described, vary only within relatively narrow limits, and present on the whole as great fixity as the higher plants. It certainly supports his view to discover, on subjecting to a careful investigation *Botrydium granulatum*, a Siphonaceous Alga whose varied forms had been described by Rostafinski and Woronin, that these authors had included in the life-cycle, stages of a second Alga described previously by Kützing, and now described afresh by Klebs as *Protosiphon botryoides*. In *Botrydium* the chromatophores are small, without pyrenoids, and oil-drops are present; in *Protosiphon* the chromatophores form a network with pyrenoids, and the contents include starch. Klebs insists that the only solution of such problems is the subjection of the Algæ in question to a rigorous method of pure culture. It is interesting to learn that Senn, pursuing the methods described by Klebs, has confirmed Chodat's observation of the passage of *Raphidium* into a *Dactylococcus*-stage, although he was unable to observe further metamorphosis. He has also seen *Pleurococcus viridis* dividing so as to form a filament, but has not succeeded in seeing the formation of zoospores as described by Chodat. While, therefore, there is much evidence of a negative character against the existence of an extensive polymorphism among Algæ, some amount of metamorphosis is known to occur. But until the conditions under which a particular transformation takes place have been ascertained and described, so that the observation may be repeated by other investigators, scant credence is likely to be given to the more extreme polymorphistic views.

Physiology.

In comparison with the higher plants, Algæ exhibit so much simplicity of structure, while the conditions under which they grow are so much more readily controlled, that they have frequently been the subject of physiological investigation with a view chiefly to the application of the results to the study of the higher plants. (See PHYSIOLOGY OF PLANTS). In the literature of vegetable physiology there has thus accumulated a great body of facts relating not only to the phenomena of reproduction, but also to the nutrition of Algæ. With reference to their chemical physiology, the gelatinization of the cell-wall, which is so marked a feature, is doubtless attributable to the occurrence along with cellulose of pectic compounds. There is, however, considerable variation in the nature of the membrane in different species; thus the cell-wall of *Œdogonium*, treated with sulphuric acid and iodine, turns a bright blue, while the colour is very faint in the case of *Spirogyra*, the wall of which is said to consist for the most part of pectose. While starch occurs commonly as a cell-content in the majority of the Green Algæ no trace of it occurs in *Vaucheria* and some of its allies, nor is it known in the whole of the *Phæophyceæ* and *Rhodophyceæ*. In certain *Euphæophyceæ* bodies built up of concentric layers, and attached to the chromatophores, were described by Schmitz as phæophycean-starch; they do not, however, give the ordinary starch reaction. Other granules, easily mistaken for the "starch" granules, are also found in the cells of *Phæophyceæ*; these possess a power of movement apart from the protoplasm, and are considered to be vesicles and to contain phloroglucin. The colourless granules of *Florideæ*, which are supposed to constitute the carbohydrate reserve material, have been called floridean-starch. A white efflorescence which appears on certain Brown Algæ (*Saccorhiza bulbosa*, *Laminaria saccharina*), when they are dried in the air, is found to consist of mannite. Mucin is known in the cell-sap of Acetabularia. Some *Siphonales* (*Codium*) give rise to proteid crystalloids, and they are of constant occurrence among *Florideæ*. The presence of tannin has been established in the case of a great number of freshwater Algæ.

Colouring-matters.

By virtue of the possession of chlorophyll all Algæ are capable of utilizing carbonic acid gas as a source of carbon in the presence of sunlight. The presence of phycocyanin, phycophæin, and phycoerythrin considerably modifies the absorption spectra for the plants in which they occur. Thus in the case of phycoerythrin the maximum absorption, apart from the great absorption at the blue end of the spectrum, is not, as in the case where chlorophyll occurs alone, near the Fraunhofer line B, but farther to the right beyond the line D. By an ingenious method devised by Engelmann, it may be shown that the greatest liberation of oxygen, and consequently the greatest assimilation of carbon, occurs in that region of the spectrum represented by the absorption bands. In this connexion Pfeffer points out that the penetrating power of light into a clear sea varies for light of different colours. Thus red light is reduced to such an extent as to be insufficient for growth at a depth of 34 metres, yellow light at a depth of 177 metres, and green light at 322 metres. It is thus an obvious advantage to Red Algæ, which flourish at considerable depths, to be able to utilize yellow light rather than the red, which is extinguished so much sooner. The experiment of Engelmann referred to deserves to be mentioned here, if only in illustration of the use to which Algæ have been put in the study of physiological problems. Engelmann observed that certain Bacteria were motile only in the presence of oxygen, and that they retained their motility in a microscopic preparation in the neighbourhood of an Algal filament when they had come to rest elsewhere on account of the exhaustion of oxygen. After the Bacteria had all been brought to rest by being placed in the dark, he threw a spectrum upon the filament, and observed in what region the Bacteria first regained their motility, owing to the liberation of oxygen in the process of carbon-assimilation. He found that these places corresponded closely with the region of the absorption band for the Algæ under experiment.

Although Algæ generally are able to use carbonic acid gas as a source of carbon, some Algæ, like certain of the higher plants, are capable of utilizing organic compounds for this purpose. Thus *Spirogyra* filaments, which have been denuded of starch by being placed in the dark, form starch in one day if they are placed in a 10 to 20 per cent. solution of dextrose. According to Bokorny, moreover, it appears that such filaments will yield starch from formaldehyde when they are supplied with sodium oxymethyl sulphonate, a salt which readily decomposes into formaldehyde and hydrogen sodium sulphite, an observation which has been taken to mean that formaldehyde is always a stage in the synthesis of starch. With reference to the assimilation of nitrogen, it would seem that Algæ, like other green plants, can best use it when it is presented to them in the form of a nitrate. Some Algæ, however, seem to flourish better in the presence of organic compounds. In the case of *Scenedesmus acutus*, it is said that the Alga is unable to take up nitrogen in the form of a nitrate or ammoniacal salt, and requires some such substance as an amide or a peptone. On the other hand it has been held by Frank and other observers that atmospheric nitrogen is fixed by the agency of Green Algæ in the soil. (For the remarkable symbiotism between Algæ and Fungi, see FUNGI.)

Excepting where the thallus is impregnated with silica, as in *Diatomaceæ*, or carbonate of lime, as in *Corallinaceæ*, *Characeæ*, and some *Siphonales*, it is perhaps not surprising that Algæ should not have been extensively preserved in the fossil form. Considering, however, that it is gener-

Occurrence in the rocks.

ally believed that *Bryophyta* and vascular plants are descended from an Algal ancestry, it is natural to suppose that, prior to the luxuriant vegetable growths of the Carboniferous period, there must have existed an age of Algæ. It was doubtless this expectation that has led to the description of a number of Silurian and Devonian remains as Algæ upon what is now regarded as indequate evidence. The geologic record is, as perhaps is to be expected, exceedingly poor, except as regards the Calcareous Siphonales, which are well represented at various horizons, from the Silurian to the Tertiary; even the *Diatomaceæ*, which are found in great quantities in the Tertiary deposits, do not occur at all earlier than the chalk. It is believed, however, that the Devonian fossil, *Nematophycus*, is a Laminarian Alga, but it is not until the late Secondary and the Tertiary formations that fossil remains of Algæ become frequent. (See PALÆOBOTANY).

The subjoined list includes the larger standard works on Algæ, together with a number of papers to which reference is made in this article. For a detailed catalogue of Algological literature, see the "Bibliotheca Phycologica" in De Toni's *Sylloge Algarum*, vol. i. (1889), with the addendum thereto in vol. iv. (1897) of the same work.

General. AGARDH, J. G. *Species, genera, et ordines Algarum*, vols. i.-iii., Lund, 1848-98; *Analecta Algologica*, Lund, 1892-96; *Till Algernes Systematik*, Lund, 1872-99.—ARESCHOUG, J. E. "Observationes Phycologicæ," *Nova Acta reg. soc. sci. Upsaliensis.* Upsala, 1866-75.—BLACKMAN, F. F. "The Primitive Algæ and the Flagellata," *Ann. of Botany*, vol. xiv. Oxford, 1900. BORNET, E., and THURET, G. *Notes Algologiques.* Fasc. i.-ii. Paris, 1876-80.—DANGEARD, P. A. "Recherches sur les Algues inférieures," *Ann. des Sci. Naturelles, Bot.*, vol. vii. Paris, 1888.—DERBES, A., and SOLIER, A. J. J. *Mémoire de la Physiologie des Algues.* Paris, 1856.—DE TONI, J. B. *Sylloge Algarum*, vol. i., *Chlorophyceæ*; vol. ii., *Bacillariaceæ*; vol. iii., *Fucoideæ*; vol. iv., *Florideæ* (in progress). Padua, 1889.—FALKENBERG, P. "Die Algen im weitesten Sinne," Schenk's *Handbuch der Botanik*, vol. ii., 1882.—FARLOW, W. G. *Marine Algæ of New England.* Washington, 1881.—HARVEY, W. H. *Phycologia Britannica*, 4 vols., London, 1846-55; *Nereis Boreali-Americana*, 3 pts., Washington, 1851-58; *Phycologia Australica*, 5 vols., London, 1858-63.—HAUCK, F. "Die Meeresalgen Deutschlands und Oesterreichs," Rabenhort's *Kryptogamen-Flora.* Leipzig, 1885. —KJELLMAN, F. R. *The Algæ of the Arctic Sea.* Stockholm, 1883. —KÜTZING, F. T. *Tabulæ Phycologicæ.* 19 vols. Nordhausen, 1845-69.—KUCKUCK, P. *Beiträge zur Kenntniss der Meeresalgen.* Kiel and Leipzig, 1897-99.—MURRAY, G. *Phycological Memoirs*, London, 1892-95; *An Introduction to the Study of Seaweeds*, London, 1895.—NAEGELI, C. *Die neueren Algensysteme.* Zurich, 1847.—PRINGSHEIM, N. "Beiträge zur Morphologie der Meeresalgen," *Abhand. Königl. Akad. der Wissensch.* Berlin, 1862.—REINKE, J. *Atlas Deutscher Meeresalgen.* Berlin, 1889-92.—SCHÜTT, F. *Das Pflanzenleben der Hochsee.* Leipzig, 1893.—STACKHOUSE, J. *Nereis Britannica*, ed. i., Bath, 1801; ed. ii., Oxford, 1816.—THURET, G., and BORNET, E. *Études phycologiques.* Paris, 1878.—TURNER, D. *Historia Fucorum.* 4 vols. London, 1808-19.—ZANARDINI, G. *Iconographia Phycologica Adriatica.* Venice, 1860-76.

1. Cyanophyceæ. BORNET, E., and FLAHAULT, CH. "Revision des Nostocacées hétérocystées," *Ann. des Sc. Naturelles, Bot.*, vols. iii.-vii. Paris, 1887-88.—GOMONT, M. "Monographie des Oscillariées." *Ann. des Sc. Naturelles, Bot.*, vols. xv.-xvi. Paris, 1893.—HEGLER. "Über Kerntheilungserscheinungen," *Ref. Botan. Centralbl.*, vol. lxiv. Cassel, 1895.—KIRCHNER, O. "Schizophyceæ," in Engler and Prantl's *Pflanzenfamilien.* Leipzig, 1900.

2. Chlorophyceæ. BORZI, A. "Studi anamorfici di alcune alghe verdi," *Bull. Soc. Bot. Ital.* in *N. Giorn. Bot. Ital.*, vol. xxii. Pisa, 1890.—CHODAT, R. "On the Polymorphism of the Green Algæ," *Ann. of Botany*, vol. xi. Oxford, 1897.—COOKE, M. C. *British Freshwater Algæ*, 2 vols., London, 1882-84; *British Desmids*, London, 1887.—KLEBS, G. *Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen.* Jena, 1896.—SOLMS-LAUBACH, H. GRAF ZU. "Monograph of the Acetabulariaceæ," *Trans. Linn. Soc. (Lond.) Bot.* London, 1895.—WILLE, N. "Chlorophyceæ," in Engler and Prantl's *Pflanzenfamilien.* Leipzig, 1897.

3. Phæophyceæ. BATTERS, E. A. L. "On Ectocarpus secundus," *Grevillea*, vol. xxi. London, 1893.—BERTHOLD, G. "Die geschlechtliche Fortpflanzung der eigentlichen Phaeosporeen," *Mitth. Zool. Stat. Neapel*, vol. ii. Leipzig, 1881.—BRENNER, G. "On the Classification of the Tilopteridaceæ," *Proc. Bristol Nat. Soc.*, vol. viii. Bristol, 1896-97.—CHURCH, A. H. "On the Polymorphy of Cutleria multifida," *Ann. of Botany*, vol. xii. Oxford, 1898.—FARMER, J. B., and WILLIAMS, J. LL. "Contributions to our Knowledge of the Life-history and Cytology of Fucaceæ," *Phil. Trans. Roy. Soc.*, vol. cxc. London, 1898.—JANCZEWSKI, E. "Observations sur l'accroissement du thalle des Phæosporées," *Mém. Soc. Nat. de Sc.* Cherbourg, 1895.—KJELLMAN, F. R. "Phæophyceæ" in Engler and Prantl's *Pflanzenfamilien.* Leipzig, 1897.—OLTMANNS, F. "Beiträge zur Kenntniss der Fucaceen," *Bibliotheca botanica*, xiv. Cassall, 1889.—SAUVAGEAU, C. "Observations relatives à la sexualité des Phæosporées," *Journal de Botanique*, vol. x. Paris, 1896.—STRASBURGER, E. "Kerntheilung und Befruchtung bei Fucus," *Cytologische Studien.* Berlin, 1897.—SCHÜTT, F. *Die Peridinien der Plankton-Expedition.* Keil and Leipzig, 1895.—VALIANTE, R. *Le Cystoseiræ del Golfo di Napoli.* Leipzig, 1883.—WILLIAMS, J. LL. "On the Antherozoids of Dictyota and Taonia," *Ann. of Botany*, vol. xi. Oxford, 1897.

4. Rhodophyceæ. BERTHOLD, G. "Die Bangiacen des Golfes von Neapel," *Mitth. Zool. Stat. Neapel.* Naples, 1882.—OLTMANNS, FR. "Zur Entwickelungsgeschichte der Florideen," *Botanische Zeitung*, 1898.—PHILLIPS, R. W. "The Development of the Cystocarp in Rhodymeniales," i. and ii. *Annals of Botany*, vols. xi. xii. Oxford, 1897-98.—SCHMITZ, F. "Untersuchungen über die Befruchtung der Florideen," *Sitzungsber. der konigl. Akad. der Wissensch.* Berlin, 1883; "Kleinere Beiträge zur Kenntniss der Florideen," *La Nuova Notarisia*, 1892-94.—SCHMITZ, F., FALKENBERG, P., HAUPTFLEISCH, P. "Rhodophyceæ," in Engler and Prantl's *Pflanzenfamilien.* 1897.—SCHMIDLE, W. "Die Befruchtung, Keimung und Haarinsertion von Batrachospermum," *Bot. Zeitung.* 1899.—SIRODOT. *Les Batrachospermes.* Paris, 1884. WILLE, N. "Ueber die Befruchtung bei Nemalion multifidum," *Ber. d. deutschen bot. Gesellsc.* Band xii. Berlin, 1894.

(R. W. P.)

Algarve, the southernmost province of Portugal, coinciding with the modern district of Faro, with an area of 1872 square miles and population 228,635—a density of 122 inhabitants to the square mile. The coast is fringed for a distance of 30 miles, from Quarteira to Tavira, with long sandy islands, through which there are six passages, the most important being the New Bar, between Faro and Olhão. In 1896 the fisheries yielded 61,132 tons of herring, valued at £79,100; in 1897, 76,845 tons, valued at £68,200; and in 1898, 65,637 tons, valued at £56,900. The sardines caught in the same years averaged £73,250 in value. The capital is Faro.

Algebra, Universal.—1. This term (employed by Sylvester in a rather more restricted sense) has come to be used to denote the comparative study of algebra in general, as distinguished from its applications, and from the detailed exposition of any special variety of it. It is not easy to give a thoroughly satisfactory definition of algebra; for the purpose of this article "an algebra" will be taken to mean a mathematical calculus in which symbolical expressions of certain conventional types are constructed, and their relations investigated according to a fixed consistent system of formal rules of equivalence. This definition, imperfect as it is, will at least serve to indicate the essentially formal and abstract nature of algebraic reasoning. Whether a particular symbolism is to be regarded as an algebra or not depends partly upon its formal development, partly upon the sense attributed to the term "mathematical." Thus, for instance, the methods of symbolic logic have produced a calculus which is generally recognized to be an algebra, because it admits of a formal treatment which is independent of the particular meaning originally given to its symbols; while, on the other hand, the "equations" of chemistry, although symbolical in form, are not deductions from a limited number of fundamental equivalences, and for this reason are not regarded as algebraical. It is conceivable that, in course of time, a new algebra may be invented, suggested by chemistry and admitting of a chemical interpretation, and in fact a certain analogy has been observed between the graphic symbols of organic chemistry and the umbral notation introduced by Aronhold into the theory of algebraic forms.

2. What will here be called "ordinary" algebra developed very gradually as a kind of shorthand, devised to abbreviate the discussion of arithmetical problems and the statement of arithmetical facts. Although the distinction is one which cannot be ultimately maintained, it is convenient to classify the signs of algebra into symbols of quantity (usually figures or letters), symbols of operation, such as $+$, $\surd$, and symbols of distinction, such as brackets. Even when the formal evolution of the science was fairly complete, it was taken for granted that its symbols of quantity invariably stood for numbers, and that its symbols of operation were restricted to their ordinary arithmetical meanings. It could not escape notice that one and the same symbol, such as $\surd(a-b)$, or even $(a-b)$, sometimes did and sometimes did not admit of arithmetical interpretation, according to the values attributed to the letters involved. This led to a prolonged controversy on the nature of negative and imaginary quantities, which was ultimately settled in a very curious way. The progress of analytical geometry led to a geometrical interpretation both of negative and also of imaginary quantities; and when a "meaning," or, more properly, an interpretation, had thus been found for the symbols in question, a reconsideration of the old algebraic problem became inevitable, and the true solution, now so obvious, was eventually obtained. It was at last realized that the laws of algebra do not depend for their validity upon any particular interpretation, whether arithmetical, geometrical, or other; the only question is whether these laws do or do not involve any logical contradiction. When this fundamental truth had been fully grasped, mathematicians began to inquire whether algebras might not be discovered which obeyed laws different from those obtained by the generalization of arithmetic. The answer to this question has been so manifold as to be almost embarrassing. All that can be done here is to give a sketch of the more important and independent "special algebras" at present known to exist.

3. Although the results of ordinary algebra will be taken for granted, it is convenient to give the principal rules upon which it is based. They are

$$(a+b)+c=a+(b+c) \quad (\text{A}) \qquad (a\times b)\times c=a\times(b\times c) \quad (\text{A}')$$
$$a+b=b+a \quad (\text{C}) \qquad a\times b=b\times a \quad (\text{C}')$$
$$a(b+c)=ab+ac \quad (\text{D})$$
$$(a-b)+b=a \quad (\text{I}) \qquad (a\div b)\times b=a \quad (\text{I}')$$

These formulæ express the *associative* and *commutative* laws of the operations $+$ and $\times$, the *distributive* law of $\times$, and the definitions of the *inverse* symbols $-$ and $\div$, which are assumed to be unambiguous. The special symbols 0 and 1 are used to denote $a-a$ and $a\div a$. They behave exactly like the corresponding symbols in arithmetic; and it follows from this that whatever "meaning" is attached to the symbols of quantity, ordinary algebra includes arithmetic, or at least an image of it. Every ordinary algebraic quantity may be regarded as of the form $a+\beta\surd-1$, where a, β are "real"; that is to say, every algebraic equivalence remains valid when its symbols of quantity are interpreted as complex numbers of the type $a+\beta\surd-1$ (cf. NUMBER). But the symbols of ordinary algebra do not necessarily denote numbers; they may, for instance, be interpreted as coplanar points or vectors. Evolution and involution are usually regarded as operations of ordinary algebra; this leads to a notation for powers and roots, and a theory of irrational algebraic quantities analogous to that of irrational numbers.

Non-numerical algebra.

4. The only known type of algebra which does not contain arithmetical elements is substantially due to Boole. Although originally suggested by formal logic, it is most simply interpreted as an algebra of regions in space. Let i denote a definite region of space; and let a, b, etc., stand for definite parts of i. Let $a+b$ denote the region made up of a and b together (the common part, if any, being reckoned only once), and let $a\times b$ or ab mean the region common to a and b. Then $a+a=aa=a$; hence numerical coefficients and indices are not required. The inverse symbols $-$, $\div$ are ambiguous, and in fact are rarely used. Each symbol a is associated with its *supplement* $\bar{a}$ which satisfies the equivalences $a+\bar{a}=i$, $a\bar{a}=0$, the latter of which means that a and $\bar{a}$ have no region in common. Finally, there is a *law of absorption* expressed by $a+ab=a$. From every proposition in this algebra a reciprocal one may be deduced by interchanging $+$ and $\times$, and also the symbols 0 and i. For instance, $x+y=x+\bar{x}y$ and $xy=x(\bar{x}+y)$ are reciprocal. The operations $+$ and $\times$ obey all the ordinary laws A, C, D (§ 3).

Möbius's barycentric calculus.

5. A point A in space may be associated with a (real, positive, or negative) numerical quantity a, called its *weight*, and denoted by the symbol aA. The sum of two weighted points aA, βB is, by definition, the point $(a+\beta)$G, where G divides AB so that AG : GB $=\beta:a$. It can be proved by geometry that

$$(a\text{A}+\beta\text{B})+\gamma\text{C}=a\text{A}+(\beta\text{B}+\gamma\text{C})=(a+\beta+\gamma)\text{P},$$

where P is in fact the centroid of masses a, β, γ placed at A, B, C respectively. So, in general, if we put

$$a\text{A}+\beta\text{B}+\gamma\text{C}+\ \ldots\ +\lambda\text{L}=(a+\beta+\gamma+\ \ldots\ +\lambda)\text{X}.$$

X is, in general, a determinate point, the *barycentre* of aA, βB, etc. (or of A, B, etc. for the weights a, β, etc.). If $(a+\beta+\ \ldots\ +\lambda)$ happens to be zero, X lies at infinity in a determinate direction; unless $-a$A is the barycentre of βB, γC, ... λL, in which case $a\text{A}+\beta\text{B}+\ \ldots\ +\lambda\text{L}$ vanishes identically, and X is indeterminate. If ABCD is a tetrahedron of reference, any point P in space is determined by an equation of the form

$$(a+\beta+\gamma+\delta)\text{P}=a\text{A}+\beta\text{B}+\gamma\text{C}+\delta\text{D}:$$

a, β, γ, δ are, in fact, equivalent to a set of homogeneous co-ordinates of P. For constructions in a fixed plane three points of reference are sufficient. It is remarkable that Möbius employs the symbols AB, ABC, ABCD in their ordinary geometrical sense as lengths, areas, and volumes, except that he distinguishes their sign; thus AB $=-$BA, ABC $=-$ACB, and so on. If he had happened to think of them as "products," he might have anticipated Grassmann's discovery of the extensive calculus. From a merely formal point of view, we have in the barycentric calculus a set of "special symbols of quantity" or "extraordinaries" A, B, C, etc., which combine with each other by means of operations $+$ and $-$ which obey the ordinary rules, and with ordinary algebraic quantities by operations $\times$ and $\div$, also according to the ordinary rules, except that division by an extraordinary is not used.

Hamilton's quaternions.

6. A quaternion is best defined as a symbol of the type

$$q=\Sigma a_s e_s=a_0e_0+a_1e_1+a_2e_2+a_3e_3,$$

where $e_0\ldots e_3$ are independent extraordinaries and $a_0\ldots a_3$ ordinary algebraic quantities, which may be called the co-ordinates of q. The sum and product of two quaternions are defined by the formulæ

$$\Sigma a_s e_s + \Sigma \beta_s e_s = \Sigma(a_s + \beta_s)e_s$$
$$\Sigma a_r e_r \times \Sigma \beta_s e_s = \Sigma a_r \beta_s e_r e_s,$$

where the products $e_r e_s$ are further reduced according to the following multiplication table, in which, for example,

	e_0	e_1	e_2	e_3
e_0	e_0	e_1	e_2	e_3
e_1	e_1	$-e_0$	e_3	$-e_2$
e_2	e_2	$-e_3$	$-e_0$	e_1
e_3	e_3	e_2	$-e_1$	$-e_0$

the second line is to be read $e_1e_0 = e_1$, $e_1^2 = -e_0$, $e_1e_2 = e_3$, $e_1e_3 = -e_2$. The effect of these definitions is that the sum and the product of two quaternions are also quaternions; that addition is associative and commutative; and that multiplication is associative and distributive, but not commutative. Thus $e_1e_2 = -e_2e_1$, and if q, q' are any two quaternions, qq' is generally different from $q'q$. The symbol e_0 behaves exactly like 1 in ordinary algebra; Hamilton writes 1, i, j, k instead of e_0, e_1, e_2, e_3, and in this notation all the special rules of operation may be summed up by the equalities

$$i^2 = j^2 = k^2 = ijk = -1.$$

Putting $q = a + \beta i + \gamma j + \delta k$, Hamilton calls a the *scalar part* of q, and denotes it by Sq; he also writes Vq for $\beta i + \gamma j + \delta k$, which is called the *vector part* of q. Thus every quaternion may be written in the form $q = Sq + Vq$, where either Sq or Vq may separately vanish; so that ordinary algebraic quantities (or *scalars*, as we shall call them) and pure vectors may each be regarded as special cases of quaternions.

The equatione $q' + x = q$ and $y + q' = q$ are satisfied by the same quaternion, which is denoted by $q - q'$. On the other hand, the equations $q'x = q$ and $yq' = q$ have, in general, different solutions. It is the value of y which is generally denoted by $q \div q'$; a special symbol for x is desirable, but has not been established. If we put $q'_0 = Sq' - Vq'$, then q'_0 is called the *conjugate* of q', and the scalar $q'q'_0 = q'_0q'$ is called the *norm* of q' and written Nq'. With this notation the values of x and y may be expressed in the forms—

$$x = q'_0 q/Nq', \qquad y = qq'_0/Nq',$$

which are free from ambiguity, since scalars are commutative with quaternions. The values of x and y are different, unless $V(qq'_0) = 0$.

In the applications of the calculus the co-ordinates of a quaternion are usually assumed to be numerical; when they are complex, the quaternion is further distinguished by Hamilton as a *biquaternion*. Clifford's biquaternione are quantities $\xi q + \eta r$, where q, r are quaternions, and ξ, η are symbols (commutative with quaternions) obeying the laws $\xi^2 = \xi$, $\eta^2 = \eta$, $\xi\eta = \eta\xi = 0$.

Grassmann's extensive calculus.

7. In the extensive calculus of the nth category, we have, first of all, n independent "units," $e_1, e_2, \ldots e_n$. From these are derived symbols of the type

$$A_1 = a_1e_1 + a_2e_2 + \ldots + a_ne_n = \Sigma ae,$$

which we shall call *extensive quantities of the first species* (and, when necessary, of the nth category). The *co-ordinates* $a_1, \ldots a_n$ are scalars, and in particular applications may be restricted to real or complex numerical values.

If $B_1 = \Sigma\beta e$, there is a law of addition expressed by

$$A_1 + B_1 = \Sigma(a_i + \beta_i)e_i = B_1 + A_1;$$

this law of addition is associative as well as commutative. The inverse operation is free from ambiguity, and, in fact,

$$A_1 - B_1 = \Sigma(a_i - \beta_i)e_i.$$

To multiply A_1 by a scalar, we apply the rule

$$\xi A_1 = A_1\xi = \Sigma(\xi a_i)e_i,$$

and similarly for division by a scalar.

All this is analogous to the corresponding formulæ in the barycentric calculus and in quaternions; it remains to consider the multiplication of two or more extensive quantities. The binary products of the units e_i are taken to satisfy the equalities

$$e_i^2 = 0, \quad e_ie_j = -e_je_i;$$

this reduces them to $\frac{1}{2}n(n-1)$ distinct values, exclusive of zero. These values are assumed to be independent, so we have $\frac{1}{2}n(n-1)$ *derived units of the second species or order.* Associated with these new units there is a system of extensive quantities of the second species, represented by symbols of the type

$$A_2 = \Sigma a_i E_i^{(2)} \qquad [i = 1, 2, \ldots \tfrac{1}{2}n(n-1)],$$

where $E_1^{(2)}$, $E_2^{(2)}$, etc., are the derived units of the second species. If $A_1 = \Sigma a_ie_i$, $B_1 = \Sigma\beta_ie_i$, the distributive law of multiplication is preserved by assuming

$$A_1B_1 = \Sigma(a_i\beta_i)e_ie_j;$$

it follows that $A_1B_1 = -B_1A_1$, and that $A_1^2 = 0$.

By assuming the truth of the associative law of multiplication, and taking account of the reducing formulæ for binary products, we may construct derived units of the third, fourth ... nth species. Every unit of the rth species which does not vanish is the product of r different units of the first species; two such units are independent unless they are permutations of the same set of primary units e_i, in which case they are equal or opposite according to the usual rule employed in determinants. Thus, for instance—

$$e_1.e_2e_3 = e_1e_2.e_3 = e_1e_2e_3 = -e_2e_1e_3 = e_2e_3e_1;$$

and, in general, the number of distinct units of the rth species in the nth category $(r < n)$ is $C_{n,r}$. Finally, it is assumed that (in the nth category) $e_1e_2e_3 \ldots e_n = 1$, the suffixes being in their natural order.

Let $A_r = \Sigma aE^{(r)}$ and $B_s = \Sigma\beta E^{(s)}$ be two extensive quantities of species r and s; then if $r + s < n$, they may be multiplied by the rule

$$A_rB_s = \Sigma(a\beta)E^{(r)}E^{(s)}$$

where the products $E^{(r)}E^{(s)}$ may be expressed as derived units of species $(r + s)$. The product B_sA_r is equal or opposite to A_rB_s, according as rs is even or odd. This process may be extended to the product of three or more factors such as $A_rB_sC_t \ldots$ provided that $r + s + t + \ldots$ does not exceed n. The law is associative; thus, for instance, $(AB)C = A(BC)$. But the commutative law does not always hold; thus, indicating species, as before, by suffixes, $A_rB_sC_t = (-1)^{rs+st+tr}\,C_tB_sA_r$, with analogous rules for other cases.

If $r + s > n$, a product such as E_rE_s, worked out by the previous rules, comes out to be zero. A characteristic feature of the calculus is that a meaning can be attached to a symbol of this kind by adopting a new rule, called that of *regressive* multiplication, as distinguished from the foregoing, which is *progressive*. The new rule requires some preliminary explanation. If E is any extensive unit, there is one other unit E′, and only one, such that the (progressive) product EE′ = 1. This unit is called the supplement of E, and denoted by |E. For example, when $n = 4$,

$$|e_1 = e_2e_3e_4, \quad |e_1e_2 = e_3e_4, \quad |e_2e_3e_4 = -e_1,$$

and so on. Now when $r + s > n$, the product E_rE_s is defined to be that unit of which the supplement is the progressive product $|E_r|E_s$. For instance, if $n = 4$, $E_r = e_1e_3$, $E_s = e_2e_3e_4$, we have

$$|E_r|E_s = (-e_2e_4)(-e_1) = e_1e_2e_4 = |e_3,$$

consequently, by the rule of regressive multiplication,

$$e_1e_3.e_2e_3e_4 = e_3.$$

Applying the distributive law, we obtain, when $r + s > n$,

$$A_rB_s = \Sigma\alpha E_r\Sigma\beta E_s = \Sigma(\alpha\beta)E_rE_s,$$

where the regressive products E_rE_s are to be reduced to units of species $(r + s - n)$ by the foregoing rule.

If $A = \Sigma\alpha E$, then, by definition, $A = \Sigma\alpha|E$, and hence

$$A|(B + C) = A|B + A|C.$$

Now this is formally analogous to the distributive law of multiplication; and in fact we may look upon $A|B$ as a particular way of multiplying A and B (not A and $|B$). The symbol $A|B$, from this point of view, is called the *inner* product of A and B, as distinguished from the *outer* product AB. An inner product may be either progressive or regressive. In the course of reducing such expressions as (AB)C, (AB){C(DE)} and the like, where a chain of multiplications has to be performed in a certain order, the multiplications may be all progressive, or all regressive, or partly one, partly the other. In the first two cases the product is said to be *pure*, in the third case *mixed*. A pure product is associative; a mixed product, speaking generally, is not.

The outer and inner products of two extensive quantities A, B, are in many ways analogous to the quaternion symbols Vab and Sab respectively. As in quaternions, so in the extensive calculus, there are numerous formulæ of transformation which enable us to deal with extensive quantities without expressing them in terms of the primary units. Only a few illustrations can be given here. Let a, b, c, d, e, f be quantities of the first species in the fourth category; A, B, C ... quantities of the third species in the same category. Then

$$\begin{gathered}(de)(abc) = (abde)c + (cade)b + (bcde)a \\ = (abce)d - (abcd)e, \\ (ab)(AB) = (aA)(bB) - (aB)(bA) \\ ab|c = (a|c)b - (b|c)a, \quad (ab|cd) = (a|c)(b|d) - (a|d)(b|c).\end{gathered}$$

These may be compared and contrasted with such quaternion formulæ as

$$\begin{gathered}S(VabVcd) = SadSbc - SacSbd \\ dSabc = aSbcd - bScda + cSadb\end{gathered}$$

where a, b, c, d denote arbitrary vectors.

Linear algebras.

8. An n-tuple linear algebra (also called a complex number-system) deals with quantities of the type $A = \Sigma\alpha_ie_i$ derived from n special units $e_1, e_2 \ldots e_n$. The sum and product of two quantities are defined in the first instance by the formulæ

$$\Sigma\alpha e + \Sigma\beta e = \Sigma(\alpha + \beta)e, \quad \Sigma\alpha_ie_i \times \Sigma\beta_je_j = \Sigma(\alpha_i\beta_j)e_ie_j,$$

so that the laws A, C, D of § 3 are satisfied. The binary products e_ie_j, however, are expressible as linear functions of the units e_i by means of a "multiplication table" which defines the special characteristics of the algebra in question. Multiplication may or may not be commutative, and in the same way it may or may not be associative. The types of linear associative algebras, not assumed to be commutative, have been enumerated (with some omissions) up to sextuple algebras inclusive by B. Peirce. Quaternions afford an example of a quadruple algebra of this kind. If, in the extensive calculus of the nth category, all the units (including 1 and the derived units E) are taken to be homologous instead of being distributed into species, we may regard it as a $(2^n - 1)$-tuple linear algebra, which, however, is not wholly associative. It should be observed that while the use of special units, or extraordinaries, in a linear algebra is convenient, especially in applications, it is not indispensable. Any linear quantity may be denoted by a symbol $(\alpha_1, \alpha_2, \ldots \alpha_n)$ in which only its scalar coefficients occur; in fact, the special units only serve, in the algebra proper, as *umbræ* or regulators of certain operations on scalars (see NUMBER, § 33). This idea finds fuller expression in the algebra of matrices, as to which it must suffice to say that a matrix is a symbol consisting of a rectangular array of scalars, and that matrices may be combined by a rule of addition which obeys the usual laws, and a rule of multiplication which is distributive and associative, but not, in general, commutative. Various special algebras (for example, quaternions) may be expressed in the notation of the algebra of matrices.

Subsidiary algebras.

9. The algebras discussed up to this point may be considered as independent in the sense that each of them deals with a class of symbols of quantity more or less homogeneous, and a set of operations applying to them all. But when an algebra is used with a particular interpretation, or even in the course of its formal development, it frequently happens that new symbols of operation are, so to speak, superposed upon the algebra, and are found to obey certain formal laws of combination of their own. For instance, there are the symbols Δ, D, E used in the calculus of finite differences; Aronhold's symbolical method in the calculus of invariants; and the like. In most cases these subsidiary algebras, as they may be called, are inseparable from the applications in which they are used; but in any attempt at a natural classification of algebra (at present a hopeless task), they would have to be taken into account. Even in ordinary algebra the notation for powers and roots disturbs the symmetry of the rational theory; and when a schoolboy illegitimately extends the distributive law by writing $\sqrt{(a + b)} = \sqrt{a} + \sqrt{b}$, he is unconsciously emphasizing this want of complete harmony.

10. The reader cannot fail to observe that this article is far from being an outline of universal algebra, in the sense ascribed to that term at the beginning; it is, rather, a brief presentation of some of the principal facts with which universal algebra has to deal. It may even be doubted whether any theory of universal algebra, except in a very restricted or provisional sense, is actually possible at present. It may, perhaps, be admitted that we have arrived at the conception that an "algebraic quantity" is a symbol defined *merely* by its formal relations; and that the symbols + and × are legitimately used when the first is commutative and associative, and the second distributive. But there is hardly any other general statement that may not be upset by future discoveries; and in fact even these are inconsistent with much current notation. The state of mathematical symbolism to-day may be fairly compared to that of botany, when the idea of a natural classification first began to suggest itself.

Authorities.—A. DE MORGAN, "On the Foundation of Algebra," *Trans. Camb. P. S.* vii. viii. 1839-1844; G. PEACOCK, *Symbolical Algebra*, Cambridge, 1845; G. BOOLE, *Laws of Thought*, London, 1854; E. SCHRÖDER, *Lehrbuch der Arithmetik u. Algebra*, Leipzig, 1873, *Vorlesungen über die Algebra der Logik*, ibid. 1877 &c.; A. F. MÖBIUS, *Der barycentrische Calcul*, Leipzig, 1827 (reprinted in M.'s collected works, vol. i. Leipzig, 1885); W. R. HAMILTON, *Lectures on Quaternions*, Dublin, 1853, *Elements of Quaternions*, ibid. 1866; H. GRASSMANN, *Die lineale Ausdehnungslehre*, Leipzig, 1844, *Die Ausdehnungslehre*, Berlin, 1862 (these are reprinted with valuable emendations and notes in *H. G.'s Gesammelte math. u. phys. Werke*, vol. i. Leipzig (2 parts), 1894, 1896), and papers in *Grunert's Arch.* vi., *Crelle*, xlix. lxxxiv., *Math. Ann.* vii. xii.; B. and C. S. PEIRCE, "Linear Associative Algebra," *Amer. Journ. Math.* iv. (privately circulated, 1871); A. CAYLEY, on Matrices, *Phil. Trans.* cxlviii., on Multiple Algebra, *Quart. M. Journ.* xxii.; J. J. SYLVESTER, on Universal Algebra (*i.e.* Matrices), *Amer. Journ. Math.* vi.; H. J. S. SMITH, on Linear Indeterminate Equations, *Phil. Trans.* cli.; R. S. BALL, *Theory of Screws*, Dublin, 1876; and papers in *Phil. Trans.* clxiv. and *Trans. R. Ir. Ac.* xxv.; W. K. CLIFFORD, on Biquaternions, *Proc. L. M. S.* iv.; A. BUCHHEIM, on Extensive Calculus and its applications, *Proc. L. M. S.* xv.-xvii.; H. TABER, on Matrices, *Amer. J. M.* xii.; K. WEIERSTRASS, "Zur Theorie der aus *n* Haupteinheiten gebildeten complexen Grossen," *Götting. Nachr.* 1884; G. FROBENIUS, on Bilinear Forms, *Crelle*, lxxxiv. and *Berl. Ber.* 1896; L. KRONECKER, on Complex Numbers and Modular Systems, *Berl. Ber.* 1888; G. SCHEFFERS, "Complexe Zahlensysteme," *Math. Ann.* xxxix. (this contains a bibliography up to 1890); S. LIE, *Vorlesungen über continuirliche Gruppen*, Leipzig, 1893 (chap. 21). For a more complete account of the literature, and a general view of the subject, the reader may consult H. HANKEL, *Theorie der complexen Zahlensysteme*, Leipzig, 1867; O. STOLZ, *Vorlesungen über allgemeine Arithmetik*, ibid. 1883; A. N. WHITEHEAD, *A Treatise on Universal Algebra, with Applications*, vol. i. Cambridge, 1898 (a very comprehensive work, to which the writer of this article is in many ways indebted); and the *Encyclopädie d. math. Wissenschaften*, vol. i. Leipzig, 1898, &c. §§ A 1 (H. Schubert), A 4 (E. Study), and B 1 *c* (G. Landsberg). For the history of the development of ordinary algebra M. Cantor's *Vorlesungen über Geschichte der Mathematik* is the standard authority. (G. B. M.)

ALGEBRAIC FORMS.

THE subject-matter of algebraic forms is to a large extent connected with the linear transformation of algebraical polynomials which involve two or more variables. The theories of determinants and of symmetric functions and of the algebra of differential operations have an important bearing upon this comparatively new branch of mathematics. They are the chief instruments of research, and have themselves much benefited by being so employed. When a homogeneous polynomial is transformed by general linear substitutions as hereafter explained, and is then expressed in the original form with new coefficients affecting the new variables, certain functions of the new coefficients and variables are numerical multiples of the same functions of the original coefficients and variables. The investigation of the properties of these functions, as well for a single form as for a simultaneous set of forms, and as well for one as for many series of variables, is included in the theory of invariants. As far back as 1773 Lagrange, and later Gauss, had met with simple cases of such functions; Boole, in 1841 (*Camb. Math. Journ.* iii. pp. 1-20), made important steps, but it was not till 1845 that Cayley (*Coll. Math. Papers*, i. pp. 80-94, 95-112) showed by his calculus of hyper-determinants that an infinite series of such functions might be obtained systematically. The subject was carried on over a long series of years by himself, Sylvester, Salmon, Hesse, Aronhold, Hermite, Brioschi, Clebsch, Gordan, &c. The year 1868 saw a considerable enlargement of the field of operations. This arose from the study by Klein and Lie of a new theory of groups of substitutions; it was shown that there exists an invariant theory connected with every group of linear substitutions. The invariant theory then existing was classified by them as appertaining to "finite continuous groups." Other "Galois" groups were defined whose substitution coefficients have fixed numerical values, and are particularly associated with the theory of equations. Arithmetical groups, connected with the theory of quadratic forms and other branches of the theory of numbers, which are termed "discontinuous," and infinite groups connected with differential forms and equations, came into existence, and also particular linear and higher transformations connected with analysis and geometry. The effect of this was to co-ordinate many branches of mathematics and greatly to increase the number of workers. The subject of transformation in general has been treated by Sophus Lie in the classical work *Theorie der Transformationsgruppen*. The present article is merely concerned with algebraical linear transformation. Two methods of treatment have been carried on in parallel lines, the unsymbolic and the symbolic; both of these originated with Cayley, but he with Sylvester and the English school have in the main confined themselves to the former, whilst Aronhold, Clebsch, Gordan, and the Continental schools have principally restricted themselves to the latter. The two methods have been conducted so as to be in constant touch, though the nature of the results obtained by the one differs much from those which flow naturally from the other. Each has been singularly successful in discovering new lines of advance and in encouraging the other to renewed efforts. Gordan first proved that for any system of forms there exists a finite number of covariants, in terms of which all others are expressible as rational and integral functions. This enabled Hilbert to produce a very simple unsymbolic proof of the same theorem. So the theory of the forms appertaining to a binary form of unrestricted order was first worked out by Cayley and MacMahon by unsymbolic methods, and later Stroh, from a knowledge of the results, was able to verify and extend the results by the symbolic method. At the moment of writing no English work exists on the symbolic methods, so that it has been judged proper to present to English readers a short *résumé* of those processes, and to refer them for other information to the existing English treatises. The partition method of treating symmetrical algebra is one which has been singularly successful in indicating new paths of advance in the theory of invariants; the important theorem of expressibility is, directly we exclude unity from the partitions, a theorem concerning the expressibility of covariants, and involves the theory of the reducible forms and of the syzygies. The theory brought forward has not yet found a place in any systematic treatise in any language, so that it has been judged proper to give a fairly complete account of it.

I. THE THEORY OF DETERMINANTS.

Let there be given n^2 quantities

$$\begin{array}{ccccc} a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \dots & a_{3n} \\ \cdot & \cdot & \cdot & \dots & \cdot \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn} \end{array}$$

and form from them a product of n quantities

$$a_{1\alpha}\,a_{2\beta}\,a_{3\gamma}\,\dots\,a_{n\nu}$$

Where the first suffixes are the natural numbers 1, 2, 3, ... n taken in order, and $\alpha, \beta, \gamma, \dots \nu$ is some permutation of these n numbers. This permutation by a transposition of two numbers, say α, β, becomes $\beta, \alpha, \gamma, \dots \nu$, and by successively transposing pairs of letters the permutation can be reduced to the form 1, 2, 3, ... n. Let k such transpositions be necessary; then the expression

$$\Sigma(-)^k a_{1\alpha}a_{2\beta}a_{3\gamma}\dots a_{n\nu},$$

the summation being for all permutations of the n numbers, is called the determinant of the n^2 quantities. The quantities $a_{1\alpha}, a_{2\beta} \dots$ are called the elements of the determinant; the term $(-)^k a_{1\alpha}a_{2\beta}a_{3\gamma}\dots a_{n\nu}$ is called a member of the determinant, and there are evidently $n!$ members corresponding to the $n!$ permutations of the n numbers 1, 2, 3, ... n. The determinant is usually written

$$\Delta = \begin{vmatrix} a_{11} & a_{12} & a_{13} & & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \dots & a_{3n} \\ \cdot & \cdot & \cdot & \dots & \cdot \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn} \end{vmatrix}$$

the square array being termed the *matrix* of the determinant. A matrix has in many parts of mathematics a signification apart from its evaluation as a determinant. A theory of matrices has been constructed by Cayley in connexion particularly with the theory of linear transformation. The matrix consists of n rows and n columns. Each row as well as each column supplies one and only one element to each member of the determinant. Consideration of the definition of the determinant shows that the value is unaltered when the suffixes in each element are transposed.

Theorem.—If the determinant is transformed so as to read by columns as it formerly did by rows its value is unchanged. The *leading member* of the determinant is $a_{11}a_{22}a_{33}\ldots a_{nn}$, and corresponds to the *principal diagonal* of the matrix.

We write frequently

$$\Delta = \Sigma \pm a_{11}a_{22}a_{33}\ldots a_{nn} = (a_{11}a_{22}a_{33}\ldots a_{nn}).$$

If the first two columns of the determinant be transposed the expression for the determinant becomes $\Sigma(-)^h a_{1\beta}a_{2\alpha}a_{3\gamma}\ldots a_{n\nu}$, viz., α and β are transposed, and it is clear that the number of transpositions necessary to convert the permutation $\beta\alpha\gamma\ldots\nu$ of the second suffixes to the natural order is changed by unity. Hence the transposition of columns merely changes the sign of the determinant. Similarly it is shown that the transposition of any two columns or of any two rows merely changes the sign of the determinant.

Theorem.—Interchange of any two rows or of any two columns merely changes the sign of the determinant.

Corollary.—If any two rows or any two columns of a determinant be identical the value of the determinant is zero.

Minors of a Determinant.—From the value of Δ we may separate those members which contain a particular element a_{ik} as a factor, and write the portion $a_{ik}\,A_{ik}$; A_{ik}, the cofactor of a_{ik}, is called a minor of order $n-1$ of the determinant.

Now $a_{11}A_{11} = \Sigma \pm a_{11}a_{22}a_{33}\ldots a_{nn}$, wherein a_{11} is not to be changed, but the second suffixes in the product $a_{22}a_{33}\ldots a_{nn}$ assume all permutations, the number of transpositions necessary determining the sign to be affixed to the member.

Hence $a_{11}A_{11} = a_{11}\Sigma \pm a_{22}a_{33}\ldots a_{nn}$, where the cofactor of a_{11} is clearly the determinant obtained by erasing the first row and the first column.

$$\text{Hence } A_{11} = \begin{vmatrix} a_{22} & a_{32} & \ldots & a_{n2} \\ a_{23} & a_{33} & \ldots & a_{3n} \\ \cdot & \cdot & \cdots & \cdot \\ a_{n2} & a_{n3} & \ldots & a_{nn} \end{vmatrix}$$

Similarly A_{ik}, the cofactor of a_{ik}, is shown to be the product of $(-)^{i+k}$ and the determinant obtained by erasing from Δ the i^{th} row and k^{th} column. No member of a determinant can involve more than one element from the first row. Hence we have the development

$$\Delta = a_{11}A_{11} + a_{12}A_{12} + a_{13}A_{13} + \ldots + a_{1n}A_{1n},$$

proceeding according to the elements of the first row and the corresponding minors.

Similarly we have a development proceeding according to the elements contained in any row or in any column, viz.,

$$\left.\begin{aligned} \Delta &= a_{i1}A_{i1} + a_{i2}A_{i2} + a_{i3}A_{i3} + \ldots + a_{in}A_{in} \\ \Delta &= a_{1k}A_{1k} + a_{2k}A_{2k} + a_{3k}A_{3k} + \ldots + a_{nk}A_{nk} \end{aligned}\right\}(A).$$

This theory enables the evaluation of a determinant by successive reduction of the orders of the determinants involved.

Ex. gr.

$$\begin{vmatrix} 1 & 0 & 3 \\ 2 & 1 & 6 \\ 0 & -5 & 3 \end{vmatrix} = 1\begin{vmatrix} 1 & 6 \\ -5 & 3 \end{vmatrix} - 0\begin{vmatrix} 2 & 6 \\ 0 & -3 \end{vmatrix} + 3\begin{vmatrix} 2 & 1 \\ 0 & -5 \end{vmatrix}$$
$$= 1\,|\,3\,| - 6\,|-5\,| + 3.2\,|-5\,| - 3.1\,|\,0\,|$$
$$= 3 + 30 - 30 - 0 = 3.$$

Since the determinant

$$\begin{vmatrix} a_{21} & a_{22} & a_{23} & \ldots & a_{2n} \\ a_{21} & a_{22} & a_{23} & \ldots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \ldots & a_{3n} \\ \cdot & \cdot & \cdot & \cdots & \cdot \\ a_{n1} & a_{n2} & a_{n3} & \ldots & a_{nn} \end{vmatrix}, \text{ having two identical rows,}$$

vanishes identically; we have by development according to the elements of the first row

$$a_{21}A_{11} + a_{22}A_{12} + a_{23}A_{13} + \ldots + a_{2n}A_{1n} = 0;$$

and, in general, since

$$a_{i1}A_{i1} + a_{i2}A_{i2} + a_{i3}A_{i3} + \ldots + a_{in}A_{in} = \Delta,$$

if we suppose the i^{th} and k^{th} rows identical

$$a_{k1}A_{i1} + a_{k2}A_{i2} + a_{k3}A_{i3} + \ldots + a_{kn}A_{in} = 0 \quad (k \gtrless i);$$

and proceeding by columns instead of rows,

$$a_{1i}A_{1k} + a_{2i}A_{2k} + a_{3i}A_{3k} + \ldots + a_{ni}A_{nk} = 0 \quad (k \gtrless i)$$

identical relations always satisfied by these minors.

If in the first relation of (A) we write $a_{ik} = b_{ik} + c_{ik} + d_{ik} + \ldots$ we find that $\Sigma a_{ik}A_{ik} = \Sigma b_{ik}A_{ik} + \Sigma c_{ik}A_{ik} + \Sigma d_{ik}A_{ik} + \ldots$ so that Δ breaks up into a sum of determinants, and we also obtain a theorem for the addition of determinants which have $n-1$ rows in common. If we multiply the elements of the second row by an arbitrary magnitude λ, and add to the corresponding elements of the first row, Δ becomes $\Sigma a_{1k}A_{1k} + \lambda\Sigma a_{2k}A_{1k} = \Sigma a_{1k}A_{1k} = \Delta$, showing that the value of the determinant is unchanged. In general we can prove in the same way the—

Theorem.—The value of a determinant is unchanged if we add to the elements of any row or column the corresponding elements of the other rows or other columns respectively each multiplied by an arbitrary magnitude, such magnitude remaining constant in respect of the elements in a particular row or a particular column.

Observation.—Every factor common to all the elements of a row or of a column is obviously a factor of the determinant, and may be taken outside the determinant brackets.

Ex. gr.

$$\begin{vmatrix} \alpha^2 & \beta^2 & \gamma^2 \\ \alpha & \beta & \gamma \\ 1 & 1 & 1 \end{vmatrix} = \begin{vmatrix} \alpha^2 & \beta^2-\alpha^2 & \gamma^2-\alpha^2 \\ \alpha & \beta-\alpha & \gamma-\alpha \\ 1 & 0 & 0 \end{vmatrix} = \begin{vmatrix} \beta^2-\alpha^2 & \gamma-\alpha^2 \\ \beta-\alpha & \gamma-\alpha \end{vmatrix}$$
$$= (\beta-\alpha)(\gamma-\alpha)\begin{vmatrix} \beta+\alpha & \gamma+\alpha \\ 1 & 1 \end{vmatrix} = (\beta-\gamma)(\gamma-\alpha)\begin{vmatrix} \beta-\gamma & \gamma+\alpha \\ 0 & 1 \end{vmatrix}$$
$$= (\beta-\alpha)(\gamma-\alpha)(\beta-\gamma).$$

The minor A_{ik} is $\dfrac{\partial\Delta}{\partial a_{ik}}$, and is itself a determinant of order $n-1$. We may therefore differentiate again in regard to any element a_{rs} where $r \gtrless i$, $s \gtrless k$; we will thus obtain a minor of A_{ik}, which is a minor also of Δ of order $n-2$. It will be $A_{\substack{ik\\rs}} = \dfrac{\partial A_{ik}}{\partial a_{rs}} = \dfrac{\partial^2\Delta}{\partial a_{ik}\partial a_{rs}}$ and will be obtained by erasing from the determinant A_{ik} the row and column containing the element a_{rs}; this was originally the r^{th} row and s^{th} column of Δ; the r^{th} row of Δ is the r^{th} or $(r-1)^{th}$ row of A_{ik} according as $r \lesseqgtr i$ and the s^{th} column of Δ is the s^{th} or $s-1^{th}$ column of A_{ik} according as $s \gtrless k$. Hence, if T_{ri} denote the number of transpositions necessary to bring the succession ri into ascending order of magnitude, the sign to be attached to the determinant arrived at by erasing the i^{th} and r^{th} rows and the k^{th} and s^{th} columns from Δ in order produce $A_{\substack{ik\\rs}}$ will be -1 raised to the power of $T_{ri} + T_{ks} + i + k + r + s$.

Similarly proceeding to the minors of order $n-3$, we find that $A_{\substack{ik\\rs\\tu}} = \dfrac{\partial}{\partial a_{tu}} A_{\substack{ik\\rs}} = \dfrac{\partial^2}{\partial a_{rs}\partial a_{tu}} A_{ik} = \dfrac{\partial^3}{\partial a_{ik}\partial a_{rs}\partial a_{tu}}\Delta$ is obtained from Δ by erasing the i^{th}, r^{th}, t^{th} rows, the k^{th}, s^{th}, u^{th} columns, and multiplying the resulting determinant by -1 raised to the power $T_{tri} + T_{usk} + i + k + r + s + t + u$ and the general law is clear.

Corresponding Minors.—In obtaining the minor $A_{\substack{ik\\rs}}$ in the form of a determinant we erased certain rows and columns, and we would have erased in an exactly similar manner had we been forming the determinant associated with $A_{\substack{is\\rk}}$, since the deleting lines intersect in two pairs of points. In the latter case the sign is determined by -1 raised to the same power as before, with the exception that T_{uks} replaces T_{usk}; but if one of these numbers be even the other must be uneven; hence

$$A_{\substack{ik\\rs}} = -A_{\substack{is\\rk}}.$$

Moreover

$$a_{ik}a_{rs}A_{\substack{ik\\rs}} + a_{is}a_{rk}A_{\substack{is\\rk}} = \begin{vmatrix} a_{ik} & a_{is} \\ a_{rk} & a_{rs} \end{vmatrix} A_{\substack{ik\\rs}},$$

where the determinant factor is given by the four points in which the deleting lines intersect. This determinant and that associated with $A_{\substack{ik\\rs}}$ are termed corresponding determinants. Similarly p lines of deletion intersecting in p^2 points yield corresponding determinants of orders p and $n-p$ respectively. Recalling the formula

$$\Delta = a_{11}A_{11} + a_{12}A_{12} + a_{13}A_{13} + \ldots + a_{1n}A_{1n},$$

it will be seen that a_{1k} and A_{1k} involve corresponding determinants. Since A_{1k} is a determinant we similarly obtain

$$A_{1k} = a_{21}A_{\substack{1k\\21}} + \ldots + a_{2,k-1}A_{\substack{1,k\\2,k-1}} + a_{2,k+1}A_{\substack{1,k\\2,k+1}} + \ldots + a_{2,n}A_{\substack{1,k\\2,n}},$$

and thence

$$\Delta = \sum_{i,k} a_{1i}a_{2k}A_{\substack{1i\\2k}} \quad \text{where } i \gtrless k;$$

and as before

$$\Delta = \sum_{i,k} \begin{vmatrix} a_{1i} & a_{2i} \\ a_{1k} & a_{2k} \end{vmatrix} A_{\substack{1i\\2k}} \quad i > k,$$

an important expansion of Δ.

Similarly

$$\Delta = \sum_{i,k,r} \begin{vmatrix} a_{1i} & a_{2i} & a_{3i} \\ a_{1k} & a_{2k} & a_{3k} \\ a_{1r} & a_{2r} & a_{3r} \end{vmatrix} A_{\substack{1i\\2k\\3r}} \quad i > k > r.$$

and the general theorem is manifest, and yields a development in a sum of products of corresponding determinants. If the j^{th}

column be identical with the i^{th} the determinant Δ vanishes identically; hence if j be not equal to i, k, or r,

$$0=\Sigma \begin{vmatrix} a_{1j} & a_{2j} & a_{3j} \\ a_{1k} & a_{2k} & a_{3k} \\ a_{1r} & a_{2r} & a_{3r} \end{vmatrix} A_{\substack{1i\\2k\\3r}}.$$

Similarly, by putting one or more of the deleted rows or columns equal to rows or columns which are not deleted, we obtain, with Laplace, a number of identities between products of determinants of complementary orders.

Multiplication.—From the theorem given above for the expansion of a determinant as a sum of products of pairs of corresponding determinants it will be plain that the product of $\Delta=(a_{11}, a_{22},\ldots a_{nn})$ and $D=(b_{11}, b_{22}, b_{nn})$ may be written as a determinant of order $2n$, viz.—

$$\begin{vmatrix} a_{11} & a_{21} & a_{31} & \ldots & a_{n1} & -1 & 0 & 0 & \ldots & 0 \\ a_{12} & a_{22} & a_{32} & \ldots & a_{n2} & 0 & -1 & 0 & \ldots & 0 \\ a_{13} & a_{23} & a_{33} & . & a_{n3} & 0 & 0 & -1 & \ldots & 0 \\ . & . & . & \ldots & . & . & . & . & \ldots & . \\ a_{1n} & a_{2n} & a_{3n} & \ldots & a_{nn} & 0 & 0 & 0 & \ldots & -1 \\ 0 & 0 & 0 & \ldots & 0 & b_{11} & b_{12} & b_{13} & \ldots & b_{1n} \\ 0 & 0 & 0 & \ldots & 0 & b_{21} & b_{22} & b_{23} & \ldots & b_{2n} \\ 0 & 0 & 0 & \ldots & 0 & b_{31} & b_{32} & b_{33} & \ldots & b_{3n} \\ . & . & . & \ldots & . & . & . & . & \ldots & . \\ 0 & 0 & 0 & \ldots & 0 & b_{n1} & b_{n2} & b_{n3} & \ldots & b_{nn} \end{vmatrix} = \begin{vmatrix} A & B \\ C & D \end{vmatrix} \text{ for brevity.}$$

Multiply the 1^{st}, 2^{nd}, ... n^{th} rows by $b_{11}, b_{12}, \ldots b_{1n}$ respectively, and add to the $n+1^{th}$ row; by $b_{21}, b_{22}, \ldots b_{2n}$, and add to the $n+2^{th}$ row; by $b_{31}, b_{32}, \ldots b_{3n}$ and add to the $n+3^{rd}$ row, &c. C then becomes

$$\begin{vmatrix} a_{11}b_{11}+a_{12}b_{12}+\ldots+a_{1n}b_{1n}, & a_{21}b_{11}+a_{22}b_{12}+\ldots+a_{2n}b_{1n}, \\ & \ldots a_{n1}b_{11}+a_{n2}b_{12}+\ldots+a_{nn}b_{1n} \\ a_{11}b_{21}+a_{12}b_{22}+\ldots+a_{1n}b_{2n}, & a_{21}b_{21}+a_{22}b_{22}+\ldots+a_{2n}b_{2n}, \\ & \ldots a_{n1}b_{21}+a_{n2}b_{22}+\ldots+a_{nn}b_{2n} \\ a_{11}b_{31}+a_{12}b_{32}+\ldots+a_{1n}b_{3n}, & a_{21}b_{31}+a_{22}b_{32}+\ldots+a_{2n}b_{3n}, \\ & \ldots a_{n1}b_{31}+a_{n2}b_{32}+\ldots+a_{nn}b_{3n} \\ . \quad . \quad . \quad . & . \quad . \quad . \quad . \\ a_{11}b_{n1}+a_{12}b_{n2}+\ldots+a_{1n}b_{nn}, & a_{21}b_{n1}+a_{22}b_{n2}+\ldots+a_{2n}b_{nn}, \\ & \ldots a_{n1}b_{n1}+a_{n2}b_{n2}+\ldots+a_{nn}b_{nn} \end{vmatrix}$$

and all the elements of D become zero. Now by the expansion theorem the determinant becomes

$$(-)^{1+2+3+\cdots+2n}B.C=(-1)^{n(2n+1)+n}C=C.$$

We thus obtain for the product a determinant of order n. We may say that, in the resulting determinant, the element in the i^{th} row and k^{th} column is obtained by multiplying the elements in the k^{th} row of the first determinant severally by the elements in the i^{th} row of the second, and has the expression

$$a_{k1}b_{i1}+a_{k2}b_{i2}+a_{k3}b_{i3}\ldots+a_{kn}b_{in},$$

and we obtain other expressions by transforming either or both determinants so as to read by columns as they formerly did by rows.

Remark.—In particular the square of a determinant is a determinant of the same order $(b_{11}b_{22}b_{33}\ldots b_{nn})$ such that $b_{ik}=b_{ki}$; it is for this reason termed symmetrical.

The Adjoint or Reciprocal Determinant arises from $\Delta=(a_{11}a_{22}a_{33}\ldots a_{nn})$ by substituting for each element a_{ik} the corresponding minor A_{ik} so as to form $D=(A_{11}A_{22}A_{33}\ldots A_{nn})$. If we form the product $\Delta.D$ by the theorem for the multiplication of determinants we find that the element in the i^{th} row and k^{th} column of the product is

$$a_{k1}A_{i1}+a_{k2}A_{i2}+\ldots+a_{kn}A_{in},$$

the value of which is zero when k is different from i, whilst it has the value Δ when $k=i$. Hence the product determinant has the principal diagonal elements each equal to Δ and the remaining elements zero. Its value is therefore Δ^n and we have the identity

$$D.\Delta=\Delta^n \text{ or } D=\Delta^{n-1}.$$

It can now be proved that the first minor of the adjoint determinant, say B_{rs}, is equal to $\Delta^{n-2}a_{rs}$.

From the equations

$$\begin{aligned} a_{11}x_1+a_{12}x_2+a_{13}x_3+\ldots &=\xi_1, \\ a_{21}x_1+a_{22}x_2+a_{23}x_3+\ldots &=\xi_2, \\ a_{31}x_1+a_{32}x_2+a_{33}x_3+\ldots &=\xi_3, \\ . \quad . \quad . \quad . \quad \ldots \end{aligned}$$

we derive

$$\begin{aligned} \Delta x_1 &= A_{11}\xi_1+A_{21}\xi_2+A_{31}\xi_3+\cdots, \\ \Delta x_2 &= A_{12}\xi_1+A_{22}\xi_2+A_{32}\xi_3+\cdots, \\ \Delta x_3 &= A_{13}\xi_1+A_{23}\xi_2+A_{33}\xi_3+\cdots, \\ . \quad . \quad . \quad . \end{aligned}$$

and thence

$$\begin{aligned} \Delta^{n-1}\xi_1 &= B_{11}\Delta x_1+B_{12}\Delta x_2+B_{13}\Delta x_3+\cdots, \\ \Delta^{n-1}\xi_2 &= B_{21}\Delta x_1+B_{22}\Delta x_2+B_{23}\Delta x_3+\cdots, \\ \Delta^{n-1}\xi_3 &= B_{31}\Delta x_1+B_{32}\Delta x_2+B_{33}\Delta x_3+\cdots, \\ . \quad . \quad . \quad . \end{aligned}$$

and comparison of the first and third systems yields

$$B_{rs}=\Delta^{n-2}a_{rs}.$$

In general it can be proved that any minor of order p of the adjoint is equal to the complementary of the corresponding minor of the original multiplied by the $p-1^{th}$ power of the original determinant.

Theorem.—The adjoint determinant is the $n-1^{th}$ power of the original determinant. The adjoint determinant will be seen subsequently to present itself in the theory of linear equations and in the theory of linear transformation.

Determinants of Special Forms.—It was observed above that the square of a determinant when expressed as a determinant of the same order is such that its elements have the property expressed by $a_{ik}=a_{ki}$. Such determinants are called *symmetrical*. It is easy to see that the adjoint determinant is also symmetrical, viz., such that $A_{ik}=A_{ki}$, for the determinant got by suppressing the i^{th} row and k^{th} column differs only by an interchange of rows and columns from that got by suppressing the k^{th} row and i^{th} column. If any symmetrical determinant vanish and be *bordered* as shown below

$$\begin{vmatrix} a_{11} & a_{12} & a_{13} & \lambda_1 \\ a_{12} & a_{22} & a_{23} & \lambda_2 \\ a_{13} & a_{23} & a_{33} & \lambda_3 \\ \lambda_1 & \lambda_2 & \lambda_3 & . \end{vmatrix}$$

it is a perfect square when considered as a function of $\lambda_1, \lambda_2, \lambda_3$. For since $A_{11}A_{22}-A_{12}^2=\Delta a_{33}$, with similar relations, we have a number of relations similar to $A_{11}A_{22}=A_{12}^2$, and either $A_{rs}=+\surd(A_{rr}A_{ss})$ or $-\surd(A_{rr}A_{ss})$ for all different values of r and s. Now the determinant has the value

$$-\{\lambda_1^2A_{11}+\lambda_2^2A_{22}+\lambda_3^2A_{33}+2\lambda_2\lambda_3A_{23}+2\lambda_3\lambda_1A_{31}+2\lambda_1\lambda_2A_{12}\}$$

$=-\Sigma\lambda_r^2A_{rr}-2\Sigma\lambda_r\lambda_sA_{rs}$ in general, and hence by substitution

$$\pm\{\lambda_1\surd A_{11}+\lambda_2\surd A_{22}+\ldots+\lambda_n\surd A_{nn}\}^2.$$

A skew symmetric determinant has $a_{rr}=0$ and $a_{rs}=-a_{sr}$ for all values of r and s. Such a determinant when of uneven degree vanishes, for if we multiply each row by -1 we multiply the determinant by $(-1)^n=-1$, and the effect of this is otherwise merely to transpose the determinant, so that it reads by rows as it formerly did by columns, an operation which we know leaves the determinant unaltered. Hence $\Delta=-\Delta$ or $\Delta=0$. When a skew symmetric determinant is of even degree it is a perfect square. This theorem is due to Cayley, and reference may be made to Salmon's *Higher Algebra*, 4th ed. Art. 39. In the case of the determinant of order 4 the square root is

$$A_{12}A_{34}-A_{13}A_{24}+A_{14}A_{23}.$$

A *skew determinant* is one which is skew symmetric in all respects, except that the elements of the leading diagonal are not all zero. Such a determinant is of importance in the theory of orthogonal substitution. In the theory of surfaces we transform from one set of three rectangular axes to another by the substitutions

$$\begin{aligned} X &= ax+by+cz, \\ Y &= a'x+b'y+c'z, \\ Z &= a''x+b''y+c''z, \end{aligned}$$

where $X^2+Y^2+Z^2=x^2+y^2+z^2$. This relation implies six equations between the coefficients, so that only three of them are independent. Further we find

$$\begin{aligned} x &= aX+a'Y+a''Z, \\ y &= bX+b'Y+b''Z, \\ z &= cX+c'Y+c''Z, \end{aligned}$$

and the problem is to express the nine coefficients in terms of three independent quantities.

In general in space of n dimensions we have n substitutions similar to

$$X_1=a_{11}x_1+a_{12}x_2+\ldots+a_{1n}x_n,$$

and we have to express the n^2 coefficients in terms of $\frac{1}{2}n(n-1)$, independent quantities; which must be possible, because

$$X_1^2+X_2^2+\ldots+X_n^2=x_1^2+x_2^2+x_3^2+\ldots+x_n^2.$$

Let there be $2n$ equations

$$\begin{aligned} x_1 &= b_{11}\xi_1+b_{12}\xi_2+b_{13}\xi_3+\ldots, \\ x_2 &= b_{21}\xi_1+b_{22}\xi_2+b_{23}\xi_3+\ldots, \\ . \quad . & \quad . \quad . \quad . \\ X_1 &= b_{11}\xi_1+b_{21}\xi_2+b_{31}\xi_3+\ldots, \\ X_2 &= b_{12}\xi_1+b_{22}\xi_2+b_{32}\xi_3+\ldots, \\ . \quad . & \quad . \quad . \quad . \end{aligned}$$

where $b_{rr}=1$ and $b_{rs}=-b_{sr}$ for all values of r and s. There are then $\frac{1}{2}n(n-1)$ quantities b_{rs}. Let the determinant of the b's be Δ_b and B_{rs}, the minor corresponding to b_{rs}. We can eliminate the quantities $\xi_1, \xi_2, \ldots\xi_n$ and obtain n relations

$$\begin{aligned} \Delta_bX_1 &= (2B_{11}-\Delta_b)x_1 \qquad\qquad +2B_{21}x_2+2B_{31}x_3+\ldots, \\ \Delta_bX_2 &= \qquad\qquad 2B_{12}x_1+(2B_{22}-\Delta_b)x_2+2B_{32}x_3+\ldots, \\ . \quad . & \quad . \quad . \quad . \quad . \quad . \quad . \end{aligned}$$

and from these another equivalent set

$$\begin{aligned}\Delta_b x_1 &= (2B_{11}-\Delta_b)X_1 + 2B_{12}X_2 + 2B_{13}X_3 + \ldots,\\ \Delta_b x_2 &= 2B_{21}X_1 + (2B_{22}-\Delta_b)X_2 + 2B_{23}X_3 + \ldots,\\ &\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\end{aligned}$$

and now writing

$$\frac{2B_{ii}-\Delta_b}{\Delta_b}=a_{ii},\ \frac{2B_{ik}}{\Delta_b}=a_{ik},$$

we have a transformation which is orthogonal, because $\Sigma X^2=\Sigma x^2$ and the elements a_{ii}, a_{ik} are functions of the $\tfrac{1}{2}n(n-1)$ independent quantities b. We may therefore form an orthogonal transformation in association with every skew determinant which has its leading diagonal elements unity, for the $\tfrac{1}{2}n(n-1)$ quantities b are clearly arbitrary.

For the second order we may take

$$\Delta_b=\begin{vmatrix}1, & \lambda\\ -\lambda, & 1\end{vmatrix}=1+\lambda^2,$$

and the adjoint determinant is the same; hence

$$\begin{aligned}(1+\lambda^2)x_1 &= (1-\lambda^2)X_1 + 2\lambda X_2,\\ (1+\lambda^2)x_2 &= -2\lambda X_1 + (1-\lambda^2)X_2.\end{aligned}$$

Similarly, for the order 3, we take

$$\Delta_b=\begin{vmatrix}1 & \nu & -\mu\\ -\nu & 1 & \lambda\\ \mu & -\lambda & 1\end{vmatrix}=1+\lambda^2+\mu^2+\nu^2,$$

and the adjoint is

$$\begin{vmatrix}1+\lambda^2 & \nu+\lambda\mu & -\mu+\lambda\nu\\ -\nu+\lambda\mu & 1+\mu^2 & \lambda+\mu\nu\\ \mu+\lambda\nu & -\lambda+\mu\nu & 1+\nu^2\end{vmatrix},$$

leading to the orthogonal substitution

$$\begin{aligned}\Delta_b x_1 &= (1+\lambda^2-\mu^2-\nu^2)X_1 + 2(\nu+\lambda\mu)X_2 + 2(-\mu+\lambda\nu)X_3\\ \Delta_b x_2 &= 2(\lambda\mu-\nu)X_1 + (1+\mu^2-\lambda^2-\nu^2)X_2 + 2(\mu\nu+\lambda)X_3\\ \Delta_b x_3 &= 2(\lambda\nu+\mu)X_1 + 2(\mu\nu-\lambda)X_2 + (1+\nu^2-\lambda^2-\mu^2)X_3.\end{aligned}$$

Functional determinants were first investigated by Jacobi in a work *De Determinantibus Functionalibus*. Suppose n dependent variables $y_1, y_2, \ldots y_n$, each of which is a function of n independent variables $x_1, x_2, \ldots x_n$, so that $y_s=f_s(x_1, x_2, \ldots x_n)$. From the differential coefficients of the y's with regard to the x's we form the functional determinant

$$R=\begin{vmatrix}\frac{\partial y_1}{\partial x_1} & \frac{\partial y_1}{\partial x_2} & \cdots & \frac{\partial y_1}{\partial x_n}\\ \frac{\partial y_2}{\partial x_1} & \frac{\partial y_2}{\partial x_2} & \cdots & \frac{\partial y_2}{\partial x_n}\\ \cdot & \cdot & \cdots & \cdot\\ \frac{\partial y_n}{\partial x_1} & \frac{\partial y_n}{\partial x_2} & \cdots & \frac{\partial y_n}{\partial x_n}\end{vmatrix}=\begin{pmatrix}y_1, & y_2, & \ldots y_n\\ x_1, & x_2, & \ldots x_n\end{pmatrix}\ \text{for brevity.}$$

If we have new variables z such that $z_s=\phi_s(y_1, y_2, \ldots y_n)$, we have also $z_s=\psi_s(x_1, x_2, \ldots x_n)$, and we may consider the three determinants

$$\begin{pmatrix}y_1, & y_2 \ldots y_n\\ x_1, & x_2 \ldots x_n\end{pmatrix},\ \begin{pmatrix}z_1, & z_2 \ldots z_n\\ y_1, & y_2 \ldots y_n\end{pmatrix},\ \begin{pmatrix}z_1, & z_2 \ldots z_n\\ x_1, & x_2 \ldots x_n\end{pmatrix}.$$

Forming the product of the first two by the product theorem, we obtain for the element in the i^{th} row and k^{th} column

$$\frac{\partial z_i}{\partial y_1}\frac{\partial y_1}{\partial x_k}+\frac{\partial z_i}{\partial y_2}\frac{\partial y_2}{\partial x_k}+\ldots+\frac{\partial z_i}{\partial y_n}\frac{\partial y_n}{\partial x_k},$$

which is $\frac{\partial z_i}{\partial x_k}$, the partial differential coefficient of z_i with regard to x_k. Hence the product theorem

$$\begin{pmatrix}z_1, & z_2 \ldots z_n\\ y_1, & y_2 \ldots y_n\end{pmatrix}\begin{pmatrix}y_1, & y_2 \ldots y_n\\ x_1, & x_2 \ldots x_n\end{pmatrix}=\begin{pmatrix}z_1, & z_2 \ldots z_n\\ x_1, & x_2, \ \ x_n\end{pmatrix};$$

and as a particular case

$$\begin{pmatrix}y_1, & y_2 \ldots y_n\\ x_1, & x_2 \ldots x_n\end{pmatrix}\begin{pmatrix}x_1, & x_2 \ldots x_n\\ y_1, & y_2 \ldots y_n\end{pmatrix}=1.$$

Theorem.—If the functions $y_1, y_2 \ldots y_n$ be not independent of one another the functional determinant vanishes, and conversely if the determinant vanishes, $y_1, y_2 \ldots y_n$ are not independent functions of $x_1, x_2, \ldots x_n$.

Linear Equations.—It is of importance to study the application of the theory of determinants to the solution of a system of linear equations. Suppose given the n equations

$$\begin{aligned}f_1 &= a_{11}x_1+a_{12}x_2+\ldots+a_{1n}x_n=0,\\ f_2 &= a_{21}x_1+a_{22}x_2+\ldots+a_{2n}x_n=0,\\ &\cdot\quad\cdot\quad\cdot\quad\cdots\quad\cdot\\ f_n &= a_{n1}x_1+a_{n2}x_2+\ldots+a_{nn}x_n=0.\end{aligned}$$

Denote by Δ the determinant $(a_{11}a_{22}\ldots a_{nn})$.

Multiplying the equations by the minors $A_{1\mu}, A_{2\mu}, \ldots A_{n\mu}$ respectively, and adding, we obtain

$$x_\mu(a_{1\mu}A_{1\mu}+a_{2\mu}A_{2\mu}+\ldots+a_{n\mu}A_{n\mu})=x_\mu\Delta=0,$$

since from results already given the remaining coefficients of $x_1, x_2, \ldots x_{\mu-1}, x_{\mu+1}, \ldots x_n$ vanish identically.

Hence if Δ does not vanish $x_1=x_2=\ldots=x_n=0$ is the only solution; but if Δ vanishes the equations can be satisfied by a system of values other than zeros. For in this case the n equations are not independent since identically

$$A_{1\mu}f_1+A_{2\mu}f_2+\ldots+A_{n\mu}f_n=0,$$

and assuming that the minors do not all vanish the satisfaction of $n-1$ of the equations implies the satisfaction of the n^{th}.

Consider then the system of $n-1$ equations

$$\begin{aligned}a_{21}x_1+a_{22}x_2+\ldots+a_{2n}x_n&=0\\ a_{31}x_1+a_{32}x_2+\ldots+a_{3n}x_n&=0\\ \cdot\quad\cdot\quad\cdots\quad\cdot&\\ a_{n1}x_1+a_{n2}x_2+\ldots+a_{nn}x_n&=0,\end{aligned}$$

which becomes on writing $\frac{x_s}{x_n}=y_s$,

$$\begin{aligned}a_{21}y_1+a_{22}y_2+\ldots+a_{2,n-1}y_{n-1}+a_{2n}&=0\\ a_{31}y_1+a_{32}y_2+\ldots+a_{3,n-1}y_{n-1}+a_{3n}&=0\\ \cdot\quad\cdot\quad\cdots\quad\cdot\quad\cdot&\\ a_{n1}y_1+a_{n2}y_2+\ldots+a_{n,n-1}y_{n-1}+a_{nn}&=0.\end{aligned}$$

We can solve these, assuming them independent, for the $n-1$ ratios $y_1, y_2, \ldots y_{n-1}$.

Now

$$\begin{aligned}a_{21}A_{11}+a_{22}A_{12}+\ldots+a_{2n}A_{1n}&=0\\ a_{31}A_{11}+a_{32}A_{12}+\ldots+a_{3n}A_{1n}&=0\\ \cdot\quad\cdot\quad\cdots\quad\cdot&\\ a_{n1}A_{11}+a_{n2}A_{12}+\ldots+a_{nn}A_{1n}&=0.\end{aligned}$$

and therefore, by comparison with the given equations, $x_i=\rho A_{1i}$, where ρ is an arbitrary factor which remains constant as i varies.

Hence $y_i=\frac{A_{1i}}{A_{1n}}$ where A_{1i} and A_{1n} are minors of the complete determinant $(a_{11}a_{22}\ldots a_{nn})$.

$$\therefore y_i=(-)^{i+n}\frac{\begin{vmatrix}a_{21} & a_{22} & \ldots a_{2,i-1} & a_{2,i+1} & \ldots a_{2n}\\ a_{31} & a_{32} & \ldots a_{3,i-1} & a_{3,i+1} & \ldots a_{3n}\\ \cdot & \cdot & \cdots\ \cdot & \cdot & \cdots\ \cdot\\ a_{n1} & a_{n2} & \ldots a_{n,i-1} & a_{n,i+1} & \ldots a_{nn}\end{vmatrix}}{\begin{vmatrix}a_{21} & a_{22} & \ldots a_{2,n-1}\\ a_{31} & a_{32} & \ldots a_{3,n-1}\\ \cdot & \cdot & \cdots\ \cdot\\ a_{n1} & a_{n2} & \ldots a_{n,n-1}\end{vmatrix}},$$

or, in words, y_i is the quotient of the determinant obtained by erasing the i^{th} column by that obtained by erasing the n^{th} column, multiplied by $(-1)^{i+n}$. For further information concerning the compatibility and independence of a system of linear equations, see Gordan, *Vorlesungen über Invariantentheorie*, Bd. 1, § 8.

Resultants.—When we are given k homogeneous equations in k variables or k non-homogeneous equations in $k-1$ variables, the equations being independent, it is always possible to derive from them a single equation $R=0$, where in R the variables do not appear. R is a function of the coefficients which is called the "resultant" or "eliminant" of the k equations, and the process by which it is obtained is termed "elimination." We cannot combine the equations so as to eliminate the variables unless on the supposition that the equations are simultaneous, *i.e.*, each of them satisfied by a common system of values; hence the equation $R=0$ is derived on this supposition, and the vanishing of R expresses the condition that the equations can be satisfied by a common system of values assigned to the variables.

Consider two binary equations of orders m and n respectively expressed in non-homogeneous form, viz.

$$\begin{aligned}f(x)=f&=a_0x^m-a_1x^{m-1}+a_2x^{m-2}-\ldots=0,\\ \phi(x)=\phi&=b_0x^n-b_1x^{n-1}+b_2x^{n-2}-\ldots=0.\end{aligned}$$

If $\alpha_1, \alpha_2, \ldots \alpha_m$ be the roots of $f=0$, $\beta_1, \beta_2, \ldots\beta_n$ the roots of $\phi=0$, the condition that some root of $\phi=0$ may cause f to vanish is clearly

$$R_{f,\phi}=f(\beta_1)f(\beta_2)\ldots f(\beta_n)=0;$$

so that $R_{f,\phi}$ is the resultant of f and ϕ, and expressed as a function of the roots, it is of degree m in each root β, and of degree n in each root α, and also a symmetric function alike of the roots α and of the roots β; hence, expressed in terms of the coefficients, it is homogeneous and of degree n in the coefficients of f, and homogeneous and of degree m in the coefficients of ϕ.

Ex. gr.

$$f=a_0x^2-a_1x+a_2=0,\ \phi=b_0x^2-b_1x+b_2.$$

We have to multiply $a_0\beta_1^2-a_1\beta_1+a_2$ by $a_0\beta_2^2-a_1\beta_2+a_2$ and we obtain

$$a_0^2\beta_1^2\beta_2^2-a_0a_1(\beta_1^2\beta_2+\beta_1\beta_2^2)+a_0a_2(\beta_1^2+\beta_2^2)+a_1^2\beta_1\beta_2 -a_1a_2(\beta_1+\beta_2)+a_2^2,$$

where

$$\beta_1+\beta_2=\frac{b_1}{b_0},\ \beta_1\beta_2=\frac{b_2}{b_0},\ \beta_1^2+\beta_2^2=\frac{b_1^2-2b_0b_2}{b_0^2},$$

and clearing of fractions

$$R_{f,\phi}=(a_0b_2-a_2b_0)^2+(a_1b_0-a_0b_1)(a_1b_2-a_2b_1).$$

We may equally express the result as

$$\phi(a_1)\phi(a_2)\ldots\phi(a_m)=0,$$

or as

$$\prod_{s,t}(a_s-\beta_t)=0.$$

This expression of R shows that, as will afterwards appear, the resultant is a simultaneous invariant of the two forms.

The resultant being a product of mn root differences, is of degree mn in the roots, and hence is of weight mn in the coefficients of the forms; *i.e.*, the sum of the suffixes in each term of the resultant is equal to mn.

Resultant Expressible as a Determinant.—From the theory of linear equations it can be gathered that the condition that p linear equations in p variables (homogeneous and independent) may be simultaneously satisfied is expressible as a determinant, viz., if

$$\begin{aligned}a_{11}x_1+a_{12}x_2+\ldots+a_{1p}x_p&=0,\\ a_{21}x_1+a_{22}x_2+\ldots+a_{2p}x_p&=0,\\ \cdot\qquad\cdot\qquad\ldots\qquad\cdot&\\ a_{p1}x_1+a_{p2}x_2+\ldots+a_{pp}x_p&=0,\end{aligned}$$

be the system the condition is, in determinant form,

$$(a_{11}a_{22}\ldots a_{pp})=0;$$

in fact the determinant is the resultant of the equations.

Now, suppose f and ϕ to have a common factor $x-\gamma$,

$$f(x)=f_1(x)(x-\gamma);\ \phi(x)=\phi_1(x)(x-\gamma),$$

f_1 and ϕ_1 being of degrees $m-1$ and $n-1$ respectively; we have the identity $\phi_1(x)f(x)=f_1(x)\phi(x)$ of degree $m+n-1$.

Assuming then ϕ_1 to have the coefficients $B_1, B_2, \ldots B_n$
and f_1 the coefficients $A_1, A_2, \ldots A_m$,
we may equate coefficients of like powers of x in the identity, and obtain $m+n$ homogeneous linear equations satisfied by the $m+n$ quantities $B_1, B_2, \ldots B_n, A_1, A_2, \ldots A_m$. Forming the resultant of these equations we evidently obtain the resultant of f and ϕ.

Thus to obtain the resultant of

$$f=a_0x^3+a_1x^2+a_2x+a_3,\ \phi=b_0x^2+b_1x+b_2$$

we assume the identity

$$(B_0x+B_1)(a_0x^3+a_1x^2+a_2x+a_3)=(A_0x^2+A_1x+A_2)(b_0x^2+b_1x+b_2),$$

and derive the linear equations

$$\begin{aligned}B_0a_0\qquad\quad -A_0b_0\qquad\qquad\qquad &=0,\\ B_0a_1+B_1a_0-A_0b_1-A_1b_0\qquad\quad &=0,\\ B_0a_2+B_1a_1-A_0b_2-A_1b_1-A_2b_0&=0,\\ B_0a_3+B_1a_2\qquad\quad -A_1b_2-A_2b_1&=0,\\ B_1a_3\qquad\qquad\qquad -A_2b_2&=0,\end{aligned}$$

and by elimination we obtain the resultant

$$\begin{vmatrix}a_0 & 0 & b_0 & 0 & 0\\ a_1 & a_0 & b_1 & b_0 & 0\\ a_2 & a_1 & b_2 & b_1 & b_0\\ a_3 & a_2 & 0 & b_2 & b_1\\ 0 & a_3 & 0 & 0 & b_2\end{vmatrix}\quad \text{a numerical factor being disregarded.}$$

This is Euler's method. Sylvester's leads to the same expression, but in a simpler manner.

He forms n equations from f by separate multiplication by $x^{n-1}, x^{n-2}, \ldots x, 1$, in succession, and similarly treats ϕ with m multipliers $x^{m-1}, x^{m-2}, \ldots x, 1$. From these $m+n$ equations he eliminates the $m+n$ powers $x^{m+n-1}, x^{m+n-2}, \ldots x, 1$, treating them as independent unknowns. Taking the same example as before the process leads to the system of equations

$$\begin{aligned}a_0x^4+a_1x^3+a_2x^2+a_3x\qquad &=0,\\ a_0x^3+a_1x^2+a_2x+a_3&=0,\\ b_0x^4+b_1x^3+b_2x^2\qquad\qquad &=0,\\ b_0x^3+b_1x^2+b_2x\qquad &=0,\\ b_0x^2+b_1x+b_2&=0,\end{aligned}$$

whence by elimination the resultant

$$\begin{vmatrix}a_0 & a_1 & a_2 & a_3 & 0\\ 0 & a_0 & a_1 & a_2 & a_3\\ b_0 & b_1 & b_2 & 0 & 0\\ 0 & b_0 & b_1 & b_2 & 0\\ 0 & 0 & b_0 & b_1 & b_2\end{vmatrix}$$

which reads by columns as the former determinant reads by rows, and is therefore identical with the former. Bezout's method gives the resultant in the form of a determinant of order m or n, according as m is $\gtrless n$. As modified by Cayley it takes a very simple form. He forms the equation

$$f(x)\phi(x')-f(x')\phi(x)=0,$$

which can be satisfied when f and ϕ possess a common factor. He first divides by the factor $x-x'$, reducing it to the degree $m-1$ in both x and x' where $m>n$; he then forms m equations by equating to zero the coefficients of the various powers of x'; these equations involve the m powers $x^0, x, x^2, \ldots x^{m-1}$ of x, and regarding these as the unknowns of a system of linear equations the resultant is reached in the form of a determinant of order m. *Ex. gr.* Put

$$(a_0x^3+a_1x^2+a_2x+a_3)(b_0x'^2+b_1x'+b_2)-(a_0x'^3+a_1x'^2+a_2x'+a_3)(b_0x^2+b_1x+b_2)=0;$$

after division by $x-x'$ the three equations are formed

$$\begin{aligned}a_0b_0x^2+a_0b_1x+a_0b_2\qquad\qquad\qquad &=0,\\ a_0b_1x^2+(a_0b_2+a_1b_1-a_2b_0)x+a_1b_2-a_3b_0&=0,\\ a_0b_2x^2+(a_1b_2-a_3b_0)x+a_2b_2-a_3b_1\qquad &=0,\end{aligned}$$

and thence the resultant

$$\begin{vmatrix}a_0b_0 & a_0b_1 & a_0b_2\\ a_0b_1 & a_0b_2+a_1b_1-a_2b_0 & a_1b_2-a_3b_0\\ a_0b_2 & a_1b_2-a_3b_0 & a_2b_2-a_3b_1\end{vmatrix}$$

which is a symmetrical determinant.

Case of Three Variables.—In the next place we consider the resultants of three homogeneous polynomials in three variables. We can prove that if the three equations be satisfied by a system of values of the variable, the same system will also satisfy the Jacobian or functional determinant. For if u, v, w be the polynomials of orders m, n, p respectively, the Jacobian is $(u_1\, v_2\, w_3)$, and by Euler's theorem of homogeneous functions

$$\begin{aligned}xu_1+yu_2+zu_3&=mu\\ xv_1+yv_2+zv_3&=nv\\ xw_1+yw_2+zw_3&=pw;\end{aligned}$$

denoting now the reciprocal determinant by $(U_1\, V_2\, W_3)$ we obtain $Jx=muU_1+nvV_1+pwW_1$; $Jy=\ldots$, $Jz=\ldots$, and it appears that the vanishing of u, v, and w implies the vanishing of J. Further, if $m=n=p$, we obtain by differentiation

$$J+x\frac{\partial J}{\partial x}=m\left(u\frac{\partial U_1}{\partial x}+v\frac{\partial V_1}{\partial x}+w\frac{\partial W_1}{\partial x}+u_1U_1+v_1V_1+w_1W_1\right),$$

or

$$x\frac{\partial J}{\partial x}=(m-1)J+m\left(u\frac{\partial U_1}{\partial x}+v\frac{\partial V_1}{\partial x}+w\frac{\partial W_1}{\partial x}\right).$$

Hence the system of values also causes $\frac{\partial J}{dx}$ to vanish in this case; and by symmetry $\frac{\partial J}{\partial y}$ and $\frac{\partial J}{dz}$ also vanish.

The proof being of general application we may state that a system of values which causes the vanishing of k polynomials in k variables causes also the vanishing of the Jacobian, and in particular, when the forms are of the same degree, the vanishing also of the differential coefficients of the Jacobian in regard to each of the variables.

There is no difficulty in expressing the resultant by the method of symmetric functions. Taking two of the equations

$$\begin{aligned}ax^m+(by+cz)x^{m-1}+\ldots&=0,\\ a'x^n+(b'y+c'z)x^{n-1}+\ldots&=0,\end{aligned}$$

we find that, eliminating x, the resultant is a homogeneous function of y and z of degree mn; equating this to zero and solving for the ratio of y to z we obtain mn solutions; if values of y and z, given by any solution, be substituted in each of the two equations, they will possess a common factor which gives a value of x which, combined with the chosen values of y and z, yields a system of values which satisfies both equations. Hence in all there are mn such systems. If, therefore, we have a third equation, and we substitute each system of values in it successively and form the product of the mn expressions thus formed, we obtain a function which vanishes if any one system of values, common to the first two equations, also satisfies the third. Hence this product is the required resultant of the three equations.

Now by the theory of symmetric functions, any symmetric functions of the mn values which satisfy the two equations, can be expressed in terms of the coefficient of those equations. Hence, finally, the resultant is expressed in terms of the coefficients of the three equations, and since it is at once seen to be of degree mn in the coefficient of the third equation, by symmetry it must be of degrees np and pm in the coefficients of the first and second equations respectively. Its weight will be mnp (see Salmon's *Higher Algebra*, 4th ed. § 77). The general theory of the resultant of k homogeneous equations in k variables presents no further difficulties when viewed in this manner.

The expression in form of a determinant presents in general considerable difficulties. If three equations, each of the second degree, in three variables be given, we have merely to eliminate the six products x^2, y^2, z^2, yz, zx, xy from the six equations $u=v=w=\frac{\partial J}{\partial x}=\frac{\partial J}{\partial y}=\frac{\partial J}{\partial z}=0$; if we apply the same process to these equations, each of degree three, we obtain similarly a determinant of order 21, but thereafter the process fails. Cayley, however, has shown that, whatever be the degrees of the three equations, it is possible to represent the resultant as the quotient of two determinants (Salmon, *l.c.* p. 89).

Discriminants.—The discriminant of a homogeneous polynomial in k variables is the resultant of the k polynomials formed by differentiations in regard to each of the variables.

It is the resultant of k polynomials each of degree $m-1$, and thus contains the coefficients of each form to the degree $(m-1)^{k-1}$; hence the total degrees in the coefficients of the k forms is, by addition, $k(m-1)^{k-1}$; it may further be shown that the weight of each term of the resultant is constant and equal to $m(m-1)^{k-1}$ (Salmon, *l.c.* p. 100).

A binary form which has a square factor has its discriminant equal to zero. This can be seen at once because the factor in question, being once repeated in both differentials, the resultant of the latter must vanish.

Similarly, if a form in k variables be expressible as a quadratic function of $k-1$, linear functions $X_1, X_2, \ldots X_{k-1}$, the coefficients being any polynomials, it is clear that the k differentials have, in common, the system of roots derived from $X_1=X_2=\ldots=X_{k-1}=0$, and have in consequence a vanishing resultant. This implies the vanishing of the discriminant of the original form.

Expression in Terms of Roots.—Since $x\frac{\partial f}{\partial x}+y\frac{\partial f}{\partial y}=mf$, if we take any root x_1, y_1, of $\frac{\partial f}{\partial x}$, and substitute in mf we must obtain $y_1\left(\frac{\partial f}{\partial y}\right)_{\substack{x=x_1\\y=y_1}}$; hence the resultant of $\frac{\partial f}{\partial x}$ and f is, disregarding numerical factors, $y_1y_2\ldots y_{m-1}\times$ discriminant of $f=a_0\times$ disct. of f. Now

$$f=(xy_1-x_1y)(xy_2-x_2y)\ldots(xy_m-x_my),$$

$$\frac{\partial f}{\partial x}=\Sigma y_1(xy_2-x_2y)\ldots(xy_m-x_my),$$

and substituting in the latter any root of f and forming the product, we find the resultant of f and $\frac{\partial f}{\partial x}$, viz. :—

$$y_1y_2\ldots y_m(x_1y_2-x_2y_1)^2(x_1y_3-x_3y_1)^2\ldots(x_ry_s-x_sy_r)^2\ldots$$

and, dividing by $y_1y_2\ldots y_m$, the discriminant of f is seen to be equal to the product of the squares of all the differences of any two roots of the equation. The discriminant of the product of two forms is equal to the product of their discriminants multiplied by the square of their resultant. This follows at once from the fact that the discriminant is

$$\Pi(\alpha_r-\alpha_s)^2\Pi(\beta_r-\beta_s)^2\{\Pi(\alpha_r-\beta_s)\}^2.$$

References for the Theory of Determinants.—T. MUIR'S "List of Writings on Determinants," *Quarterly Journal of Mathematics*, v. 15, pp. 110-149, October 1881, is the most important bibliographical article on the subject in any language; it contains 489 entries, arranged in chronological order, the first date being 1693 and the last 1880.—T. MUIR. *History of the Theory of Determinants.* London, 1890.—School treatises are those of THOMSON, MANSION, BARTL, MOLLAME, in English, French, German, and Italian respectively.—Advanced treatises are those of SPOTTISWOODE, 1851; BRIOSCHI, 1854; BALTZER, 1857; SALMON, 1859; TRUDI, 1862; GARBIERI, 1874; GÜNTHER, 1875; DOSTOR, 1877; BARANIECKI (the most extensive of all), 1879; SCOTT, 1880; MUIR, 1881.

II. THE THEORY OF SYMMETRIC FUNCTIONS.

Consider n quantities $\alpha_1, \alpha_2, \alpha_3, \ldots \alpha_n$.

Every rational integral function of these quantities, which does not alter its value however the n suffixes 1, 2, 3, … n be permuted, is a rational integral symmetric function of the quantities. If we write $(1+\alpha_1x)(1+\alpha_2x)\ldots(1+\alpha_nx)=1+a_1x+a_2x^2+\ldots+a_nx^n$, $a_1, a_2, \ldots a_n$ are called the elementary symmetric functions.

$$a_1=\alpha_1+\alpha_2+\ldots+\alpha_n=\Sigma\alpha_1$$
$$a_2=\alpha_1\alpha_2+\alpha_1\alpha_3+\alpha_2\alpha_3+\ldots=\Sigma\alpha_1\alpha_2$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$
$$a_n=\alpha_1\alpha_2\alpha_3\ldots\alpha_n.$$

The general monomial symmetric function is

$$\Sigma\alpha_1^{p_1}\alpha_2^{p_2}\alpha_3^{p_3}\ldots\alpha_n^{p_n},$$

the summation being for all permutations of the indices which result in different terms. The function is written

$$(p_1p_2p_3\ldots p_n)$$

for brevity, and repetitions of numbers in the bracket are indicated by exponents, so that $(p_1p_1p_2)$ is written $(p_1^2p_2)$. The weight of the function is the sum of the numbers in the bracket, and the degree the highest of those numbers.

Ex. gr. The elementary functions are denoted by

$$(1), (1^2), (1^3), \ldots (1^n),$$

are all of the first degree, and are of weights 1, 2, 3, … n respectively.

Remark.—In this notation $(0)=\Sigma\alpha_1^0=\binom{n}{1}$; $(0^2)=\Sigma\alpha_1^0\alpha_2^0=\binom{n}{2}$;… $(0^s)=\binom{n}{s}$, &c. The binomial coefficients appear, in fact, as symmetric functions, and this is frequently of importance.

The order of the numbers in the bracket $(p_1p_2\ldots p_n)$ is immaterial; we may therefore always place them, as is most convenient, in descending order of magnitude; the numbers then constitute an ordered partition of the weight w, and the leading number denotes the degree.

The sum of the monomial functions of a given weight is called the *homogeneous-product-sum* or complete symmetric function of that weight; it is denoted by h_w; it is connected with the elementary functions by the formula

$$\frac{1}{1-a_1x+a_2x^2-a_3x^3+\ldots}=1+h_1x+h_2x^2+h_3x^3+\ldots,$$

which remains true when the symbols a and h are interchanged, as is at once evident by writing $-x$ for x. This proves, also, that in *any* formula connecting $a_1, a_2, a_3, \ldots$ with $h_1, h_2, h_3, \ldots$ the symbols a and h may be interchanged.

Ex. gr. from $h_2=a_1^2-a_2$ we derive $a_2=h_1^2-h_2$.

The function $\Sigma\alpha_1^{p_1}\alpha_2^{p_2}\ldots\alpha_n^{p_n}$ being as above denoted by a partition of the weight, viz. $(p_1p_2\ldots p_n)$, it is necessary to bring under view other functions associated with the same series of numbers: such, for example, as

$$\Sigma\alpha_1^{p_1}\alpha_2^{p_3}\Sigma\alpha_1^{p_2}\alpha_2^{p_4}\ldots\alpha_{n-2}^{p_{n-2}}=(p_1p_3)(p_2p_4\ldots p_{n-2}).$$

The expression just written is in fact a partition of a partition, and to avoid confusion of language will be termed a *separation* of a partition. A partition is *separated* into *separates* so as to produce a separation of the partition by writing down a set of partitions, each separate partition in its own brackets, so that when all the parts of these partitions are reassembled in a single bracket the partition which is separated is reproduced. It is convenient to write the distinct partitions or separates in descending order as regards weight. If the successive weights of the separates $w_1, w_2, w_3, \ldots$ be enclosed in a bracket we obtain a partition of the weight w which appertains to the separated partition. This partition is termed the *specification* of the separation. The degree of the separation is the sum of the degrees of the component separates. A separation is the symbolic representation of a product of monomial symmetric functions. A partition, $(p_1p_1p_1p_2p_2p_3)=(p_1^3p_2^2p_3)$, can be separated in the manner $(p_1p_2)(p_1p_3)(p_1p_2)=(p_1p_2)^2(p_1p_3)$, and we may take the general form of a partition to be $(p_1^{\pi_1}p_2^{\pi_2}p_3^{\pi_3}\ldots)$ and that of a separation $(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\ldots$ when $J_1, J_2, J_3\ldots$ denote the distinct separates involved.

Theorem.—The function symbolized by (n), viz., the sum of the n^{th} powers of the quantities, is expressible in terms of functions which are symbolized by separations of *any* partition $(n_1^{\nu_1}n_2^{\nu_2}n_3^{\nu_3}\ldots)$ of the number n. The expression is—

$$(-)^{\nu_1+\nu_2+\nu_3+\ldots}\frac{(\nu_1+\nu_2+\nu_3+\ldots-1)!}{\nu_1!\,\nu_2!\,\nu_3!\ldots}(n)$$
$$=\sum(-)^{j_1+j_2+j_3+\ldots}\frac{(j_1+j_2+j_3+\ldots-1)!}{j_1!\,j_2!\,j_3!\ldots}(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\ldots,$$

$(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\ldots$ being a separation of $(n_1^{\nu_1}n_2^{\nu_2}n_3^{\nu_3}\ldots)$ and the summation being in regard to all such separations. For the particular case $(n_1^{\nu_1}n_2^{\nu_2}n_3^{\nu_3}\ldots)=(1^n)$

$$(-)^n\frac{1}{n}(n)=\sum(-)^{j_1+j_2+j_3+\ldots}\frac{(j_1+j_2+j_3+\ldots-1)!}{j_1!\,j_2!\,j_3!\ldots}(1)^{j_1}(1^2)^{j_2}(1^3)^{j_3}\ldots$$

To establish this write—

$$1+\mu X_1+\mu^2X_2+\mu^3X_3+\ldots=\prod_{\alpha}(1+\mu\alpha_1x_1+\mu^2\alpha_1^2x_2+\mu^3\alpha_1^3x_3+\ldots),$$

the product on the right involving a factor for each of the quantities $\alpha_1, \alpha_2, \alpha_3\ldots$, and μ being arbitrary.

Multiplying out the right-hand side and comparing coefficients

$$X_1=(1)x_1,$$
$$X_2=(2)x_2+(1^2)x_1^2,$$
$$X_3=(3)x_3+(21)x_2x_1+(1^3)x_1^3,$$
$$X_4=(4)x_4+(31)x_3x_1+(2^2)x_2^2+(21^2)x_2x_1^2+(1^4)x_1^4.$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$
$$X_m=\Sigma(m_1^{\mu_1}m_2^{\mu_2}m_3^{\mu_3}\ldots)x_{m_1}^{\mu_1}x_{m_2}^{\mu_2}x_{m_3}^{\mu_3}\ldots,$$

the summation being for all partitions of m.

Auxiliary Theorem.—The coefficient of $x_{l_1}^{\lambda_1}x_{l_2}^{\lambda_2}x_{l_3}^{\lambda_3}\dots$ in the product $\frac{X_{m_1}^{\mu_1}X_{m_2}^{\mu_2}X_{m_3}^{\mu_3}\dots}{\mu_1!\,\mu_2!\,\mu_3!\dots}$ is $\sum\frac{(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\dots}{j_1!\,j_2!\,j_3!\dots}$ where $(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\dots$ is a separation of $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\dots)$ of specification $(m_1^{\mu_1}m_2^{\mu_2}m_3^{\mu_3}\dots)$, and the sum is for all such separations.

To establish this observe the result.

$$\frac{1}{p!}X_3^p=\sum\frac{(3)^{\pi_1}(21)^{\pi_2}(1^3)^{\pi_3}}{\pi_1!\pi_2!\pi_3!}x_3^{\pi_1}x_2^{\pi_2}x_1^{\pi_2+3\pi_3}$$ and remark that

$(3)^{\pi_1}(21)^{\pi_2}(1^3)^{\pi_3}$ is a separation of $(3^{\pi_1}2^{\pi_2}1^{\pi_2+3\pi_3})$ of specification (3^p). A similar remark may be made in respect of

$$\frac{1}{\mu_1!}X_{m_1}^{\mu_1},\ \frac{1}{\mu_2!}X_{m_2}^{\mu_2},\ \frac{1}{\mu_3!}X_{m_3}^{\mu_3},\dots$$

and therefore of the product of these expressions. Hence the theorem.

Now

$$\begin{aligned}&\log(1+\mu X_1+\mu^2X_2+\mu^3X_3+\dots)\\&=\sum_\alpha\log(1+\mu\alpha_1x_1+\mu^2\alpha_1^2x_2+\mu^3\alpha_1^3x_3+\dots)\end{aligned}$$

whence expanding by the exponential and multinomial theorems a comparison of the coefficients of μ^n gives

$$\begin{aligned}(\text{a})\sum(-)^{\nu_1+\nu_2+\nu_3+\dots-1}&\frac{(\nu_1+\nu_2+\nu_3+\dots-1)!}{\nu_1!\nu_2!\nu_3!\dots}x_{n_1}^{\nu_1}x_{n_2}^{\nu_2}x_{n_3}^{\nu_3}\dots\\=\sum(-)^{\nu_1+\nu_2+\nu_3+\dots-1}&\frac{(\nu_1+\nu_2+\nu_3+\dots-1)!}{\nu_1!\nu_2!\nu_3!\dots}X_{n_1}^{\nu_1}X_{n_2}^{\nu_2}X_{n_3}^{\nu_3}\dots\end{aligned}$$

and, by the auxiliary theorem, any term $X_{m_1}^{\mu_1}X_{m_2}^{\mu_2}X_{m_3}^{\mu_3}\dots$ on the right-hand side is such that the coefficient of $x_{n_1}^{\nu_1}x_{n_2}^{\nu_2}x_{n_3}^{\nu_3}\dots$ in $\frac{1}{\mu_1!\mu_2!\mu_3!\dots}X_{m_1}^{\mu_1}X_{m_2}^{\mu_2}X_{m_3}^{\mu_3}\dots$ is

$$\sum\frac{(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\dots}{j_1!j_2!j_3!\dots},$$

where since $(m_1^{\mu_1}m_2^{\mu_2}m_3^{\mu_3}\dots)$ is the specification of $(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\dots$, $\mu_1+\mu_2+\mu_3+\dots=j_1+j_2+j_3+\dots$. Comparison of the coefficients of $x_{n_1}^{\nu_1}x_{n_2}^{\nu_2}x_{n_3}^{\nu_3}\dots$ therefore yields the result

$$\begin{aligned}&(-)^{\nu_1+\nu_2+\nu_3+\dots}\frac{(\nu_1+\nu_2+\nu_3+\dots-1)!}{\nu_1!\nu_2!\nu_3!\dots}(n)\\&=\sum(-)^{j_1+j_2+j_3+\dots}\frac{(j_1+j_2+j_3+\dots-1)!}{j_1!j_2!j_3!\dots}(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\dots,\end{aligned}$$

for the expression of $\Sigma\alpha^n$ in terms of products of symmetric functions symbolized by separations of $(n_1^{\nu_1}n_2^{\nu_2}n_3^{\nu_3}\dots)$.

Let $(n)_\alpha$, $(n)_x$, $(n)_X$ denote the sums of the n^{th} powers of quantities whose elementary symmetric functions are $a_1, a_2, a_3, \dots$; $x_1, x_2, x_3, \dots$; $X_1, X_2, X_3, \dots$ respectively: then the result arrived at above from the logarithmic expansion may be written

$$(n)_\alpha(a)_x=(n)_X,$$

exhibiting $(n)_X$ as an invariant of the transformation given by the expressions of $X_1, X_2, X_3\dots$ in terms of $x_1, x_2, x_3, \dots$.

The inverse question is the expression of any monomial symmetric function by means of the power functions $(r)=s_r$. We have just seen that s_r is expressible in terms of symmetric function products symbolized by separations of any partition $(r_1^{\rho_1}r_2^{\rho_2}r_3^{\rho_3}\dots)$ of r.

Let this expression be denoted by $s(r_1^{\rho_1}r_2^{\rho_2}r_3^{\rho_3}\dots)$.

Theorem.—It can be shown that

$$\begin{aligned}&(-)^{\Sigma\pi-1}(p_1^{\pi_1}p_2^{\pi_2}p_3^{\pi_3}\dots)\\&=\sum(-)^{\Sigma j-1}\frac{(\Sigma\pi_{1t}-1)!\,(\Sigma\pi_{2t}-1)!\dots}{j_1!j_2!j_3!\dots\pi_{11}!\,\pi_{12}\dots!\,\pi_{21}!\,\pi_{22}!\dots}s_{(J_1)}^{j_1}s_{(J_2)}^{j_2}s_{(J_3)}^{j_3}\dots,\end{aligned}$$

where

$$(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\dots=(p_{11}^{\pi_{11}}p_{12}^{\pi_{12}}\dots)^{j_1}(p_{21}^{\pi_{21}}p_{22}^{\pi_{22}}\dots)^{j_2}(p_{31}^{\pi_{31}}p_{32}^{\pi_{32}}\dots)^{j_3}\dots,$$

denotes a separation of $(p_1^{\pi_1}p_2^{\pi_2}p_3^{\pi_3}\dots)$ and the summation is in regard to all such separations. If (J_1), (J_2), $(J_3)\dots$ be of weights $i_1, i_2, i_3, \dots$ it is clear that the product $s_{i_1}^{j_1}s_{i_2}^{j_2}s_{i_3}^{j_3}\dots$ will appear on the right-hand side, and that $(i_1^{j_1}i_2^{j_2}i_3^{j_3}\dots)$ is a specification of a separation of $(p_1^{\pi_1}p_2^{\pi_2}p_3^{\pi_3}\dots)$.

Ex. gr. To express (21^2) in terms of power functions.

The separations of (21^2) are (i.) (21^2), (ii.) $(21)(1)$; (iii.) $(2)(1^2)$, (iv.) $(2)(1)^2$ and the corresponding specifications (4), (31), (2^2), (21^2).

Hence the products s_4, s_3s_1, s_2^2, $s_2s_1^2$ will appear.

From the formula

$$\begin{aligned}(21^2)&=s_{(21^2)}-s_{(21)}s_{(1)}-\frac{1}{2}s_{(2)}s_{(1^2)}+\frac{1}{2}s_{(2)}s_{(1)}^2\\&=s_4-s_3s_1-\frac{1}{2}s_2^2+\frac{1}{2}s_2s_1^2,\end{aligned}$$

a result easy to verify.

Theorem of Reciprocity.—If

$$X_{m_1}^{\mu_1}X_{m_2}^{\mu_2}X_{m_3}^{\mu_3}\dots=\dots+\theta(s_1^{\sigma_1}s_2^{\sigma_2}s_3^{\sigma_3}\dots)x_{l_1}^{\lambda_1}x_{l_2}^{\lambda_2}x_{l_3}^{\lambda_3}\dots+\dots,$$

where θ is a numerical coefficient, then also

$$X_{s_1}^{\sigma_1}X_{s_2}^{\sigma_2}X_{s_3}^{\sigma_3}\dots=\dots+\theta(m_1^{\mu_1}m_2^{\mu_2}m_3^{\mu_3}\dots)x_{l_1}^{\lambda_1}x_{l_2}^{\lambda_2}x_{l_3}^{\lambda_3}\dots+\dots.$$

We have found above that the coefficient of $x_{l_1}^{\lambda_1}x_{l_2}^{\lambda_2}x_{l_3}^{\lambda_3}\dots$ in the product $X_{m_1}^{\mu_1}X_{m_2}^{\mu_2}X_{m_3}^{\mu_3}\dots$ is

$$\mu_1!\,\mu_2!\,\mu_3!\dots\sum\frac{(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\dots}{j_1!\,j_2!\,j_3!\dots},$$

the sum being for all separations of $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\dots)$ which have the specification $(m_1^{\mu_1}m_2^{\mu_2}m_3^{\mu_3}\dots)$. We can multiply out this expression so as to obtain a series of monomials of the form $\theta(s_1^{\sigma_1}s_2^{\sigma_2}s_3^{\sigma_3}\dots)$. It can be shown that the number θ enumerates distributions of a certain nature defined by the partitions $(m_1^{\mu_1}m_2^{\mu_2}\dots)$, $(s_1^{\sigma_1}s_2^{\sigma_2}\dots)$, $(l_1^{\lambda_1}l_2^{\lambda_2}\dots)$ and it is seen intuitively that the number θ remains unaltered when the first two of these partitions are interchanged (see COMBINATORIAL ANALYSIS). Hence the theorem is established.

Putting $x_1=1$ and $x_2=x_3=x_4=\dots=0$, we find a particular law of reciprocity given by Cayley and Betti,

$$\begin{aligned}(1^{m_1})^{\mu_1}(1^{m_2})^{\mu_2}(1^{m_3})^{\mu_3}\dots&=\dots+\theta(s_1^{\sigma_1}s_2^{\sigma_2}s_3^{\sigma_3}\dots)+\dots,\\(1^{s_1})^{\sigma_1}(1^{s_2})^{\sigma_2}(1^{s_3})^{\sigma_3}\dots&=\dots+\theta(m_1^{\mu_1}m_2^{\mu_2}m_3^{\mu_3}\dots)+\dots;\end{aligned}$$

and another by putting $x_1=x_2=x_3=\dots=1$, for then X_m becomes h_m, and we have

$$\begin{aligned}h_{m_1}^{\mu_1}h_{m_2}^{\mu_2}h_{m_3}^{\mu_3}\dots&=\dots+\theta'(s_1^{\sigma_1}s_2^{\sigma_2}s_3^{\sigma_3}\dots)+\dots,\\h_{s_1}^{\sigma_1}h_{s_2}^{\sigma_2}h_{s_3}^{\sigma_3}\dots&=\dots+\theta'(m_1^{\mu_1}m_2^{\mu_2}m_3^{\mu_3}\dots)+\dots.\end{aligned}$$

Theorem of Expressibility.—"If a symmetric function be symbolized by $(\lambda\mu\nu\dots)$ and $(\lambda_1\lambda_2\lambda_3\dots)$, $(\mu_1\mu_2\mu_3\dots)$, $(\nu_1\nu_2\nu_3\dots)\dots$ be any partitions of λ, μ, ν, … respectively, the function $(\lambda\mu\nu\dots)$ is expressible by means of functions symbolized by separations of

$$(\lambda_1\lambda_2\lambda_3\dots\mu_1\mu_2\mu_3\dots\nu_1\nu_2\nu_3\dots)."$$

For, writing as before,

$$\begin{aligned}X_{m_1}^{\mu_1}X_{m_2}^{\mu_2}X_{m_3}^{\mu_3}\dots&=\Sigma\Sigma\theta(s_1^{\sigma_1}s_2^{\sigma_2}s_3^{\sigma_3}\dots)x_{l_1}^{\lambda_1}x_{l_2}^{\lambda_2}x_{l_3}^{\lambda_3}\dots,\\&=\Sigma Px_{l_1}^{\lambda_1}x_{l_2}^{\lambda_2}x_{l_3}^{\lambda_3}\dots,\end{aligned}$$

P is a linear function of separations of $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\dots)$ of specification $(m_1^{\mu_1}m_2^{\mu_2}m_3^{\mu_3}\dots)$, and if $X_{s_1}^{\sigma_1}X_{s_2}^{\sigma_2}X_{s_3}^{\sigma_3}\dots=\Sigma P'x_{l_1}^{\lambda_1}x_{l_2}^{\lambda_2}x_{l_3}^{\lambda_3}\dots$, P′ is a linear function of separations of $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\dots)$ of specification $(s_1^{\sigma_1}s_2^{\sigma_2}s_3^{\sigma_3}\dots)$. Suppose the separations of $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\dots)$ to involve k different specifications and form the k identities

$$X_{m_{1s}}^{\mu_{1s}}X_{m_{2s}}^{\mu_{2s}}X_{m_{3s}}^{\mu_{3s}}\dots=\Sigma P^{(s)}x_{l_1}^{\lambda_1}x_{l_2}^{\lambda_2}x_{l_3}^{\lambda_3}\dots\ (s=1,2,\dots k),$$

where $(m_{1s}^{\mu_{1s}}m_{2s}^{\mu_{2s}}m_{3s}^{\mu_{3s}}\dots)$ is one of the k specifications.

The law of reciprocity shows that

$$P^{(s)}=\sum_{t=1}^{t=k}\theta_{st}(m_{1t}^{\mu_{1t}}m_{2t}^{\mu_{2t}}m_{3t}^{\mu_{3t}}\dots),$$

viz.:—a linear function of symmetric functions symbolized by the k specifications; and that $\theta_{st}=\theta_{ts}$. A table may be formed expressing the k expressions $P^{(1)}, P^{(2)},\dots P^{(k)}$ as linear functions of the k expressions $(m_{1s}^{\mu_{1s}}m_{2s}^{\mu_{2s}}m_{3s}^{\mu_{3s}}\dots)$, $s=1, 2, \dots k$, and the numbers θ_{st} occurring therein possess row and column symmetry. By solving k linear equations we similarly express the latter functions as linear functions of the former, and this table will also be symmetrical.

Theorem.—"The symmetric function $(m_{1s}^{\mu_{1s}}m_{2s}^{\mu_{2s}}m_{3s}^{\mu_{3s}}\dots)$ whose partition is a specification of a separation of the function symbolized by $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\dots)$ is expressible as a linear function of symmetric functions symbolized by separations of $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\dots)$ and a symmetrical table may be thus formed." It is now to be remarked that the partition $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\dots)$ can be derived from

$(m_{1s}^{\mu_{1s}}m_{2s}^{\mu_{2s}}m_{3s}^{\mu_{3s}}\ldots)$ by substituting for the numbers $m_{1s}, m_{2s}, m_{3s}, \ldots$ certain partitions of those numbers (*vide* the definition of the specification of a separation).

Hence the theorem of expressibility enunciated above. A new statement of the law of reciprocity can be arrived at as follows:—
Since

$$P^{(s)}=\mu_{1s}!\,\mu_{2s}!\,\mu_{3s}!\ldots\sum\frac{(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\ldots}{j_1!\,j_2!\,j_3!\ldots};$$

where $(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\ldots$ is a separation of $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\ldots)$ of specification $(m_{1s}^{\mu_{1s}}m_{2s}^{\mu_{2s}}m_{3s}^{\mu_{3s}}\ldots)$, placing s under the summation sign to denote the specification involved;

$$\mu_{1s}!\,\mu_{2s}!\,\mu_{3s}!\ldots\sum_s\frac{(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\ldots}{j_1!\,j_2!\,j_3!\ldots}=\sum_{t=1}^{t=k}\theta_{st}(m_{1t}^{\mu_{1t}}m_{2t}^{\mu_{2t}}m_{3t}^{\mu_{3t}}\ldots),$$

$$\mu_{1t}!\,\mu_{2t}!\,\mu_{3t}!\ldots\sum_t\frac{(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\ldots}{j_1!\,j_2!\,j_3!\ldots}=\sum_{s=1}^{s=k}\theta_{ts}(m_{1s}^{\mu_{1s}}m_{2s}^{\mu_{2s}}m_{3s}^{\mu_{3s}}\ldots),$$

where $\theta_{st}=\theta_{ts}$.

Theorem of Symmetry.—If we form the separation function $\sum\frac{(J_1)^{j_1}(J_2)^{j_2}(J_3)^{j_3}\ldots}{j_1!\,j_2!\,j_3!\ldots}$ appertaining to the function $(l_1^{\lambda_1}l_2^{\lambda_2}l_3^{\lambda_3}\ldots)$, each separation having a specification $(m_{1s}^{\mu_{1s}}m_{2s}^{\mu_{2s}}m_{3s}^{\mu_{3s}}\ldots)$, multiply by $\mu_{1s}!\,\mu_{2s}!\,\mu_{3s}!\ldots$ and take therein the coefficient of the function $(m_{1t}^{\mu_{1t}}m_{2t}^{\mu_{2t}}m_{3t}^{\mu_{3t}}\ldots)$, we obtain the same result as if we formed the separation function in regard to the specification $(m_{1t}^{\mu_{1t}}m_{2t}^{\mu_{2t}}m_{3t}^{\mu_{3t}}\ldots)$, multiplied by $\mu_{1t}!\,\mu_{2t}!\,\mu_{3t}!\ldots$ and took therein the coefficient of the function $(m_{1s}^{\mu_{1s}}m_{2s}^{\mu_{2s}}m_{3s}^{\mu_{3s}}\ldots)$.

Ex. gr., take $(l_1^{\lambda_1}l_2^{\lambda_2}\ldots)=(21^4)$; $(m_{1s}^{\mu_{1s}}m_{2s}^{\mu_{2s}}\ldots)=(321)$; $(m_{1t}^{\mu_{1t}}m_{2t}^{\mu_{2t}}\ldots)=(31^3)$; we find

$$\begin{aligned}(21)(1^2)(1)+(1^3)(2)(1)&=\ldots+13(31^3)+\ldots,\\(21)(1)^3&=\ldots+13(321)+\ldots,\end{aligned}$$

The Differential Operators.—Starting with the relation

$$(1+a_1x)(1+a_2x)\ldots(1+a_nx)=1+a_1x+a_2x^2+\ldots+a_nx^n$$

multiply each side by $1+\mu x$, thus introducing a new quantity μ; we obtain

$$(1+a_1x)(1+a_2x)\ldots(1+a_nx)(1+\mu x)=1+(a_1+\mu)x+(a_2+\mu a_1)x^2+\ldots$$

so that $f(a_1, a_2, a_3, \ldots a_n)=f$, a rational integral function of the elementary functions, is converted into

$$f(a_1+\mu,\ a_2+\mu a_1,\ldots a_n+\mu a_{n-1})=f+\mu d_1f+\frac{\mu^2}{2!}\overline{d_1^2}f+\frac{\mu^3}{3!}\overline{d_1^3}f+\ldots$$

where

$$d_1=\frac{\partial}{\partial a_1}+a_1\frac{\partial}{\partial a_2}+a_2\frac{\partial}{\partial a_3}+\ldots+a_{n-1}\frac{\partial}{\partial a_n}$$

and $\overline{d_1^s}$ denotes, not s successive operations of d_1, but the operator of order s obtained by raising d_1 to the s^{th} power symbolically as in Taylor's theorem in the Diff. Cal.

Write also $\frac{1}{s!}\overline{d_1^s}=D_s$ so that

$$f(a_1+\mu,\ a_2+\mu a_1,\ldots a_n+\mu a_{n-1})=f+\mu D_1f+\mu^2D_2f+\mu^3D_3f+\ldots.$$

The introduction of the quantity μ converts the symmetric function $(\lambda_1\lambda_2\lambda_3\ldots)$ into

$$(\lambda_1\lambda_2\lambda_3+\ldots)+\mu^{\lambda_1}(\lambda_2\lambda_3\ldots)+\mu^{\lambda_2}(\lambda_1\lambda_3\ldots)+\mu^{\lambda_3}(\lambda_1\lambda_2\ldots)+\ldots.$$

Hence, if $f(a_1, a_2, \ldots a_n)=(\lambda_1\lambda_2\lambda_3\ldots)$,

$$\begin{aligned}&(\lambda_1\lambda_2\lambda_3\ldots)+\mu^{\lambda_1}(\lambda_2\lambda_3\ldots)+\mu^{\lambda_2}(\lambda_1\lambda_3\ldots)+\mu^{\lambda_3}(\lambda_1\lambda_2\ldots)+\ldots\\&=(1+\mu D_1+\mu^2D_2+\mu^3D_3+\ldots)(\lambda_1\lambda_2\lambda_3\ldots).\end{aligned}$$

Comparing coefficients of like powers of μ we obtain

$$D_{\lambda_1}(\lambda_1\lambda_2\lambda_3\ldots)=(\lambda_2\lambda_3\ldots),$$

while $D_s(\lambda_1\lambda_2\lambda_3\ldots)=0$ unless the partition $(\lambda_1\lambda_2\lambda_3\ldots)$ contains a part s. Further, if $D_{\lambda_1}D_{\lambda_2}$ denote successive operations of D_{λ_1} and D_{λ_2},

$$D_{\lambda_1}D_{\lambda_2}(\lambda_1\lambda_2\lambda_3\ldots)=(\lambda_3\ldots),$$

and the operations are evidently commutative.

Also $D_{p_1}^{\pi_1}D_{p_2}^{\pi_2}D_{p_3}^{\pi_3}\ldots(p_1^{\pi_1}p_2^{\pi_2}p_3^{\pi_3}\ldots)=1$, and the law of operation of the operators D upon a monomial symmetric function is clear.

We have obtained the equivalent operations

$$1+\mu D_1+\mu^2D_2+\mu^3D_3+\ldots=\overline{exp}\,\mu d_1$$

where $\overline{exp}$ denotes (by the rule over *exp*) that the multiplication of operators is symbolic as in Taylor's theorem. d_1^s denotes, in fact, an operator of order s, but we may transform the right-hand side so that we are only concerned with the successive performance of linear operations. For this purpose write

$$d_s=\partial_{a_s}+a_1\partial_{a_{s+1}}+a_2\partial_{a_{s+2}}+\ldots.$$

It has been shown (*vide* "Memoir on Symmetric Functions of the Roots of Systems of Equations," *Phil. Trans. R. S.*, London, 1890, p. 490) that

$$\overline{exp}(m_1d_1+m_2d_2+m_3d_3+\ldots)=exp(M_1d_1+M_2d_2+M_3d_3+\ldots),$$

where now the multiplications on the dexter denote successive operations, provided that

$$exp(M_1\xi+M_2\xi^2+M_3\xi^3+\ldots)=1+m_1\xi+m_2\xi^2+m_3\xi^3+\ldots,$$

ξ being an undetermined algebraic quantity.

Hence we derive the particular cases

$$\overline{exp}\,d_1=exp\left(d_1-\frac{1}{2}d_2+\frac{1}{3}d_3-\ldots\right);$$

$$\overline{exp}\,\mu d_1=exp\left(\mu d_1-\frac{1}{2}\mu^2d_2+\frac{1}{3}\mu^3d_3-\ldots\right),$$

and we can express D_s in terms of $d_1, d_2, d_3, \ldots$, products denoting successive operations, by the same law which expresses the elementary function a_s in terms of the sums of powers $s_1, s_2, s_3, \ldots$. Further, we can express d_s in terms of $D_1, D_2, D_3, \ldots$ by the same law which expresses the power function s_s in terms of the elementary functions $a_1, a_2, a_3, \ldots$.

Operation of D_s *upon a Product of Symmetric Functions.*—Suppose f to be a product of symmetric functions $f_1f_2\ldots f_m$. If in the identity $f=f_1f_2\ldots f_m$ we introduce a new root μ we change a_s into $a_s+\mu a_{s-1}$, and we obtain

$$\begin{aligned}&(1+\mu D_1+\mu^2D_2+\ldots+\mu^sD_s+\ldots)f\\&=(1+\mu D_1+\mu^2D_2+\ldots+\mu^sD_s+\ldots)f_1\\&\times(1+\mu D_1+\mu^2D_2+\ldots+\mu^sD_s+\ldots)f_2\\&\times\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\\&\times(1+\mu D_1+\mu^2D_2+\ldots+\mu^sD_s+\ldots)f_m,\end{aligned}$$

and now expanding and equating coefficients of like powers of μ

$$\begin{aligned}D_1f&=\Sigma(D_1f_1)f_2f_3\ldots f_m,\\D_2f&=\Sigma(D_2f_1)f_2f_3\ldots f_m+\Sigma(D_1f_1)(D_1f_2)f_3\ldots f_m,\\D_3f&=\Sigma(D_3f_1)f_2f_3\ldots f_m+\Sigma(D_2f_1)(D_1f_2)f_3\ldots f_m+\Sigma(D_3f_1)f_2f_3\ldots f_m,\\&\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\end{aligned}$$

the summation in a term covering every distribution of the operators of the type presenting itself in the term.

Writing these results

$$\begin{aligned}D_1f&=D_{(1)}f,\\D_2f&=D_{(2)}f+D_{(1^2)}f,\\D_3f&=D_{(3)}f+D_{(21)}f+D_{(1^3)}f,\end{aligned}$$

we may write in general

$$D_sf=\Sigma D_{(p_1p_2p_3\ldots)}f,$$

the summation being for every partition $(p_1p_2p_3\ldots)$ of s, and $D_{(p_1p_2p_3\ldots)}f$ being $=\Sigma(D_{p_1}f_1)(D_{p_2}f_2)(D_{p_3}f_3)f_4\ldots f_m$.

Ex. gr. To operate with D_2 upon $(21^3)(21^4)(1^5)$, we have

$$\begin{aligned}D_{(2)}f&=(1^3)(21^4)(1^5)+(21^3)(1^4)(1^5),\\D_{(1^2)}f&=(21^2)(21^3)(1^5)+(21^2)(21^4)(1^4)+(21^3)(21^3)(1^4),\end{aligned}$$

and hence

$$\begin{aligned}D_2f=(21^4)(1^3)(1^5)+(21^3)(1^3)(1^4)+(21^2)(21^3)(1^5)+(21^3)^2(1^4)\\+(21^4)(21^2)(1^4).\end{aligned}$$

Application to Symmetric Function Multiplication.—An example will explain this. Suppose we wish to find the coefficient of (52^41^3) in the product $(21^3)(21^4)(1^5)$.

Write

$$(21^3)(21^4)(1^5)=\ldots+A(52^4)(1^3)+\ldots;$$

then

$$D_5D_2^4D_1^3(21^3)(21^4)(1^5)=A;$$

every other term disappearing by the fundamental property of D_s. Since

$$D_5(21^3)(21^4)(1^5)=(1^3)(1^4)(1^4),$$

we have:—

$$\begin{aligned}&D_2^4D_1^3(1^4)(1^4)(1^3)=A\\&D_2^3D_1^3\{(1^3)(1^3)(1^3)+2(1^4)(1^3)(1^2)\}=A\\&D_2^2D_1^3\{5(1^3)(1^3)(1^2)+2(1^4)(1^2)(1)+2(1^3)(1^3)(1)\}=A\\&D_2D_1^3\{12(1^2)(1^2)(1)+7(1^3)(1)(1)+2(1^4)(1)+6(1^3)(1^2)\}=A\\&\qquad D_1^3\,12(1)^3=A,\end{aligned}$$

where ultimately disappearing terms have been struck out. Finally $A=6.12=72$.

The operator $d_1=a_0\partial a_1+a_1\partial a_2+a_2\partial a_3+\ldots$ which is satisfied by every symmetric fraction whose partition contains no unit (called by Cayley *non-unitary symmetric functions*), is of particular importance in algebraic theories. This arises from the circumstance that the general operator

$$\lambda_0a_0\partial a_1+\lambda_1a_1\partial a_2+\lambda_2a_2\partial a_3+\ldots$$

is transformed into the operator d_1 by the substitution

$$(a_0, a_1, a_2, \ldots a_n, \ldots) = (a_0, \lambda_0 a_1, \lambda_0\lambda_1 a_2, \ldots, \lambda_0\lambda_1\ldots\lambda_{s-1}a_s, \ldots),$$

so that the theory of the general operator is coincident with that of the particular operator d_1. For example, the theory of invariants may be regarded as depending upon the consideration of the symmetric functions of the differences of the roots of the equation

$$a_0x^n - \binom{n}{1}a_1x^{n-1} + \binom{n}{2}a_2x^{n-2} - \ldots = 0;$$

and such functions satisfy the differential equation

$$a_0\partial a_1 + 2a_1\partial a_2 + 3a_2\partial a_3 + \ldots + na_{n-1}\partial a_n = 0.$$

For such functions remain unaltered when each root receives the same infinitesimal increment h; but writing $x-h$ for x causes $a_0, a_1, a_2, a_3 \ldots$ to become respectively $a_0, a_1+ha_0, a_2+2ha_1, a_3+3ha_2, \ldots$ and $f(a_0, a_1, a_2, a_3 \ldots)$ becomes

$$f + h(a_0\partial_{a_1} + 2a_1\partial_{a_2} + 3a_2\partial_{a_3} + \ldots)f,$$

and hence the functions satisfy the differential equation. The important result is that the theory of invariants is from a certain point of view coincident with the theory of non-unitary symmetric functions. On the one hand we may state that non-unitary symmetric functions of the roots of $a_0x^n - a_1x^{n-1} + a_2x^{n-2} - \ldots = 0$, are symmetric functions of differences of the roots of

$$a_0x^n - 1!\binom{n}{1}a_1x^{n-1} + 2!\binom{n}{2}a_2x^{n-2} - \ldots = 0;$$

and on the other hand that symmetric functions of the differences of the roots of

$$a_0x^n - \binom{n}{1}a_1x^{n-1} + \binom{n}{2}a_2x^{n-2} - \ldots = 0,$$

are non-unitary symmetric functions of the roots of

$$a_0x^n - \frac{a_1}{1!}x^{n-1} + \frac{a_2}{2!}x^{n-2} - \ldots = 0.$$

An important notion in the theory of linear operators in general is that of MacMahon's *multilinear operator* ("Theory of a Multilinear partial Differential Operator with Applications to the Theories of Invariants and Reciprocants," *Proc. Lond. Math. Soc.*, t. xviii. (1886), pp. 61-88). It is defined as having four elements, and is written

$$(\mu, \nu; m, n)$$

$$\begin{aligned}
=\frac{1}{m}\Big[\mu a_0^m\partial_{a_n} &+ (\mu+\nu)\frac{m!}{(m-1)!\,1!}a_0^{m-1}a_1\partial_{a_{n+1}}\\
&+(\mu+2\nu)\left\{\frac{m!}{(m-1)!\,1!}a_0^{m-1}a_2 + \frac{m!}{(m-2)!\,2!}a_0^{m-2}a_1^2\right\}\partial_{a_{n+2}}\\
&+(\mu+3\nu)\left\{\frac{m!}{(m-1)!\,1!}a_0^{m-1}a_3 + \frac{m!}{(m-2)!\,1!\,1!}a_0^{m-2}a_1a_2\right.\\
&\qquad\left.+\frac{m!}{(m-3)!\,3!}a_0^{m-3}a_0^3\right\}\partial_{a_{n+3}}\\
&+\ldots\Big],
\end{aligned}$$

the coefficient of $a_0^{k_0}a_1^{k_1}a_2^{k_2}\ldots$ being $\frac{m!}{k_0!\,k_1!\,k_2!\ldots}$. The operators $a_0\partial_{a_1} + a_1\partial_{a_2} + \ldots$, $a_0\partial_{a_1} + 2a_1\partial_{a_2} + \ldots$ are seen to be $(1, 0; 1, 1)$ and $(1, 1; 1, 1)$ respectively. Also the operator of the Theory of Pure Reciprocants (see *Sylvester Lectures on the New Theory of Reciprocants*, Oxford, 1888) is

$$(4, 1; 2, 1) = \frac{1}{2}\left\{4a_0^2\partial_{a_1} + 10a_0a_1\partial_{a_2} + 6(2a_0a_2 + a_1^2)\partial_{a_3} + \ldots\right\}$$

It will be noticed that

$$(\mu, \nu; m, n) = \mu(1, 0; m, n) + \nu(0, 1; m, n).$$

The importance of the operator consists in the fact that taking any two operators of the system

$$(\mu, \nu; m, n); (\mu^1, \nu^1; m^1, n^1),$$

the operator equivalent to

$$(\mu, \nu; m, n)(\mu^1, \nu^1; m^1, n^1) - (\mu^1, \nu^1; m^1, n^1)(\mu, \nu; m, n),$$

known as the "alternant" of the two operators, is also an operator of the same system. We have the theorem

$$(\mu, \nu; m, n)(\mu^1, \nu^1; m^1, n^1) - (\mu^1, \nu^1; m^1, n^1)(\mu, \nu; m, n) = (\mu_1, \nu_1; m_1, n_1);$$

where

$$\begin{aligned}
\mu_1 &= (m^1+m-1)\left\{\frac{\mu^1}{m^1}(\mu+n^1\nu) - \frac{\mu}{m}(\mu^1+n\nu^1)\right\},\\
\nu_1 &= (n^1-n)\nu^1\nu + \frac{m-1}{m^1}\mu^1\nu - \frac{m^1-1}{m}\mu\nu^1,\\
m_1 &= m^1+m-1,\\
n_1 &= n^1+n,
\end{aligned}$$

and we conclude that *quâ* "alternation" the operators of the system form a "group." It is thus possible to study simultaneously all the theories which depend upon operations of the group.

Symbolic Representation of Symmetric Functions.—Denote the elementary symmetric function a_s by $\frac{\alpha_1^s}{s!}, \frac{\alpha_2^s}{s!}, \frac{\alpha_3^s}{s!}, \ldots$ at pleasure; then, taking n equal to ∞, we may write

$$1 + a_1x + a_2x^2 + \ldots = (1+\rho_1x)(1+\rho_2x)\ldots = e^{\alpha_1x} = e^{\alpha_2x} = e^{\alpha_3x} = \ldots$$

where

$$a_s = \sum\rho_1\rho_2\ldots\rho_s = \frac{\alpha_1^s}{s!} = \frac{\alpha_2^s}{s!} = \frac{\alpha_3^s}{s!} = \ldots.$$

Further, let

$$1 + b_1x + b_2x^2 + \ldots + b_mx^m = (1+\sigma_1x)(1+\sigma_2x)\ldots(1+\sigma_mx);$$

so that

$$\begin{aligned}
1 + a_1\sigma_1 + a_2\sigma_1^2 + \ldots &= (1+\rho_1\sigma_1)(1+\rho_2\sigma_1)\ldots = e^{\sigma_1\alpha_1},\\
1 + a_1\sigma_2 + a_2\sigma_2^2 + \ldots &= (1+\rho_1\sigma_2)(1+\rho_2\sigma_2)\ldots = e^{\sigma_2\alpha_2},\\
\cdot \quad \cdot \quad \cdot \quad &\cdot \quad \cdot \quad \cdot \quad \cdot\\
1 + a_1\sigma_m + a_2\sigma_m^2 + \ldots &= (1+\rho_1\sigma_m)(1+\rho_2\sigma_m)\ldots = e^{\sigma_m\alpha_m};
\end{aligned}$$

and, by multiplication,

$$\begin{aligned}
\prod_\sigma(1 + a_1\sigma + a_2\sigma^2 + \ldots) &= \prod_\rho(1 + b_1\rho + b_2\rho^2 + \ldots + b_m\rho^m),\\
&= e^{\sigma_1\alpha_1+\sigma_2\alpha_2+\ldots+\sigma_m\alpha_m}.
\end{aligned}$$

Denote by brackets ( ) and [ ] symmetric functions of the quantities ρ and σ respectively. Then

$$\begin{aligned}
1 &+ a_1[1] + a_1^2[1^2] + a_2[2] + a_1^3[1^3] + a_1a_2[21] + a_3[3] + \ldots\\
&\quad + a_{p_1}a_{p_2}a_{p_3}\ldots a_{p_m}[p_1p_2p_3\ldots p_m] + \ldots\\
&= 1 + b_1(1) + b_1^2(1^2) + b_2(2) + b_1^3(1^3) + b_1b_2(21) + b_3(3) + \ldots\\
&\quad + b_1^{\pi_1}b_2^{\pi_2}b_3^{\pi_3}\ldots b_m^{\pi_m}(m^{\pi_m}\overline{m-1}^{\pi_{m-1}}\ldots 2^{\pi_2}1^{\pi_1}) + \ldots\\
&= e^{\sigma_1\alpha_1+\sigma_2\alpha_2\ldots+\sigma_m\alpha_m}.
\end{aligned}$$

Expanding the right-hand side by the exponential theorem, and then expressing the symmetric functions of $\sigma_1, \sigma_2, \ldots\sigma_m$, which arise, in terms of $b_1, b_2, \ldots b_m$, we obtain by comparison with the middle series the symbolical representation of all symmetric functions in brackets ( ) appertaining to the quantities $\rho_1, \rho_2, \rho_3, \ldots$. To obtain particular theorems the quantities $\sigma_1, \sigma_2, \sigma_3, \ldots\sigma_m$ are auxiliaries which are at our entire disposal. Thus to obtain *Stroh's theory of seminvariants* put

$$b_1 = \sigma_1 + \sigma_2 + \ldots + \sigma_m = [1] = 0;$$

we then obtain the expression of non-unitary symmetric functions of the quantities ρ as functions of differences of the symbols $\alpha_1, \alpha_2, \alpha_3, \ldots$

Ex. gr. $b_2^2(2^2)$ with $m=2$ must be a term in

$$e^{\sigma_1\alpha_1+\sigma_2\alpha_2} = e^{\sigma_1(\alpha_1-\alpha_2)} = \ldots + \frac{1}{4!}\sigma_1^4(\alpha_1-\alpha_2)^4 + \ldots,$$

and since $b_2^2 = \sigma_1^4$ we must have

$$\begin{aligned}
(2^2) &= \frac{1}{24}(\alpha_1-\alpha_2)^4 = \frac{1}{24}(\alpha_1^4+\alpha_2^4) - \frac{1}{6}(\alpha_1^3\alpha_2+\alpha_1\alpha_2^3) + \frac{1}{4}\alpha_1^2\alpha_2^2\\
&= 2a_4 - 2a_1a_3 + a_2^2
\end{aligned}$$

as is well known.

Again, if $\sigma_1, \sigma_2, \sigma_3\ldots\sigma_m$ be the m, m^{th} roots of -1, $b_1 = b_2 = \ldots = b_{m-1} = 0$ and $b_m = 1$, leading to

$$1 + (m) + (m^2) + (m^3) + \ldots = e^{\sigma_1\alpha_1+\sigma_2\alpha_2+\ldots+\sigma_m\alpha_m}$$

and

$$\therefore\ (m^s) = \frac{1}{ms!}(\sigma_1\alpha_1 + \sigma_2\alpha_2 + \ldots + \sigma_m\alpha_m)^{ms},$$

and we see further that $(\sigma_1\alpha_1 + \sigma_2\alpha_2 + \ldots + \sigma_m\alpha_m)^k$ vanishes identically unless $k \equiv 0 \bmod m$. If m be infinite and

$$1 + b_1x + b_2x^2 + \ldots = (1+\sigma_1x)(1+\sigma_2x)\ldots = e^{\beta_1x} = e^{\beta_2x} = \ldots,$$

we have the symbolic identity

$$e^{\sigma_1\alpha_1+\sigma_2\alpha_2+\sigma_3\alpha_3+\ldots} = e^{\rho_1\beta_1+\rho_2\beta_2+\rho_3\beta_3+\ldots},$$

and

$$(\sigma_1\alpha_1 + \sigma_2\alpha_2 + \sigma_3\alpha_3 + \ldots)^p = (\rho_1\beta_1 + \rho_2\beta_2 + \rho_3\beta_3 + \ldots)^p.$$

Instead of the above symbols we may use equivalent differential operators. Thus let

$$\delta_a = a_1\partial_{a_0} + 2a_2\partial_{a_1} + 3a_3\partial_{a_2} + \ldots$$

and let $a, b, c, \ldots$ be equivalent quantities. Any function of differences of $\delta_a, \delta_b, \delta_c, \ldots$ being formed the expansion being carried out, an operand a_0 or b_0 or $c_0\ldots$ being taken and $b, c, \ldots$ being subsequently put equal to a, a non-unitary symmetric function will be produced.

Ex. gr.

$$\begin{aligned}
(\delta_a-\delta_b)^2(\delta_a-\delta_c) &= (\delta_a^2 - 2\delta_a\delta_b + \delta_b^2)(\delta_a-\delta_c)\\
&= \delta_a^3 - 2\delta_a^2\delta_b + \delta_a\delta_b^2 - \delta_a^2\delta_c + 2\delta_a\delta_b\delta_c - \delta_b^2\delta_c\\
&= 6a_3 - 4a_2b_1 + 2a_1b_2 - 2a_2c_1 + 2a_1b_1c_1 - 2b_2c_1\\
&= 2(a_1^3 - 3a_1a_2 + 3a_3) = 2(3).
\end{aligned}$$

The whole theory of these forms is consequently contained implicitly in the operation δ.

Symmetric Functions of Several Systems of Quantities.—It will suffice to consider two systems of quantities as the corresponding theory for three or more systems is obtainable by an obvious enlargement of the nomenclature and notation.

Taking the systems of quantities to be

$$\alpha_1, \alpha_2, \alpha_3, \dots$$
$$\beta_1, \beta_2, \beta_3, \dots$$

we start with the fundamental relation

$$(1+\alpha_1x+\beta_1y)(1+\alpha_2x+\beta_2y)(1+\alpha_3x+\beta_3y)\dots$$
$$=1+a_{10}x+a_{01}y+a_{20}x^2+a_{11}xy+a_{02}y^2+\dots+a_{pq}x^py^q+\dots$$

As shown by Schläfli[*] this equation may be directly formed and exhibited as the resultant of two given equations, and an arbitrary linear non-homogeneous equation in two variables. The right-hand side may be also written

$$1+\Sigma\alpha_1x+\Sigma\beta_1y+\Sigma\alpha_1\alpha_2x^2+\Sigma\alpha_1\beta_2xy+\Sigma\beta_1\beta_2y^2+\dots$$

The most general symmetric function to be considered is

$$\Sigma\alpha_1^{p_1}\beta_1^{q_1}\alpha_2^{p_2}\beta_2^{q_2}\alpha_3^{p_3}\beta_3^{q_3}\dots$$

conveniently written in the symbolic form

$$(\overline{p_1q_1}\,\overline{p_2q_2}\,\overline{p_3q_3}\dots).$$

Observe that the summation is in regard to the expressions obtained by permuting the n suffixes 1, 2, 3, ...n. The weight of the function is bipartite and consists of the two numbers Σp and Σq; the symbolic expression of the symmetric function is a partition into biparts (multiparts) of the bipartite (multipartite) number $\overline{\Sigma p, \Sigma q}$. Each part of the partition is a bipartite number, and in representing the partition it is convenient to indicate repetitions of parts by power symbols. In this notation the fundamental relation is written

$$(1+\alpha_1x+\beta_1y)(1+\alpha_2x+\beta_2y)(1+\alpha_3x+\beta_3y)\dots$$
$$=1+(\overline{10})x+(\overline{01})y+(\overline{10}^2)x^2+(\overline{10}\,\overline{01})xy+(\overline{01}^2)y^2$$
$$+(\overline{10}^3)x^3+(\overline{10}^2\overline{01})x^2y+(\overline{10}\,\overline{01}^2)xy^2+(\overline{01}^3)y^3+\dots$$

where in general $a_{pq}=(\overline{10}^p\,\overline{01}^q)$.

All symmetric functions are expressible in terms of the quantities a_{pq} in a rational integral form; from this property they are termed elementary functions; further they are said to be single-unitary since each part of the partition denoting a_{pq} involves but a single unit.

The number of partitions of a biweight $\overline{pq}$ into exactly μ biparts is given (after Euler) by the coefficient of $a^\mu x^py^q$ in the expansion of the generating function

$$\frac{1}{1-ax.1-ay.1-ax^2.1-axy.1-ay^2.1-ax^3.1-ax^2y.1-axy^2.1-ay^3\dots}$$

The partitions with one bipart correspond to the sums of powers in the single system or unipartite theory; they are readily expressed in terms of the elementary functions. For write $(\overline{pq})=s_{pq}$ and take logarithms of both sides of the fundamental relation; we obtain

$$s_{10}x+s_{01}y=\Sigma(\alpha_1x+\beta_1y)$$
$$s_{20}x^2+2s_{11}xy+s_{02}y^2=\Sigma(\alpha_1x+\beta_1y)^2, \text{ \&c.},$$

and

$$s_{10}x+s_{01}y-\frac{1}{2}(s_{20}x^2+2s_{11}xy+s_{02}y^2)+\dots$$
$$=\log(1+a_{10}x+a_{01}y+\dots+a_{pq}x^py^q+\dots)$$

From this formula we obtain by elementary algebra

$$(-)^{p+q-1}\frac{(p+q-1)!}{p!\,q!}s_{pq}=\sum_\pi(-)^{\Sigma\pi-1}\frac{(\Sigma\pi-1)!}{\pi_1!\,\pi_2!\dots}a_{p_1q_1}^{\pi_1}a_{p_2q_2}^{\pi_2}\dots$$

corresponding to Waring's formula for the single system. The analogous formula appertaining to n systems of quantities which expresses $s_{pqr\dots}$ in terms of elementary functions can be at once written down.

Ex. gr. We can verify the relations

$$s_{30}=a_{10}^3-3a_{20}a_{10}+3a_{30},$$
$$s_{21}=a_{10}^2a_{01}-a_{20}a_{01}-a_{11}a_{10}+a_{21}.$$

The formula actually gives the expression of $(\overline{pq})$ by means of separations of

$$(\overline{10}^p\overline{01}^q),$$

which is one of the partitions of $(\overline{pq})$. This is the true standpoint from which the theorem should be regarded. It is but a particular case of a general theory of expressibility.

To invert the formula we may write

$$1+a_{10}x+a_{01}y+\dots+a_{pq}x^py^q+\dots$$
$$=exp\ \{(s_{10}x+s_{01}y)-\frac{1}{2}(s_{20}x^2+2s_{11}xy+s_{02}y^2)+\dots\},$$

and thence derive the formula—

$$(-)^{p+q-1}a_{pq}$$
$$=\sum\left\{\frac{(p_1+q_1-1)!}{p_1!\,q_1!}\right\}^{\pi_1}\left\{\frac{(p_2+q_2-1)!}{p_2!\,q_2!}\right\}^{\pi_2}\dots\frac{(-)^{\Sigma\pi-1}}{\pi_1!\,\pi_2!\dots}s_{p_1q_1}^{\pi_1}s_{p_2q_2}^{\pi_2}\dots,$$

which expresses the elementary functions in terms of the single bipart functions. The similar theorem for n systems of quantities can be at once written down.

It will be shown later that every rational integral symmetric function is similarly expressible.

The Function h_{pq}.—As the definition of h_{pq} we take

$$1+h_{10}x+h_{01}y+\dots+h_{pq}x^py^q+\dots$$
$$=\frac{1}{(1-\alpha_1x-\beta_1y)(1-\alpha_2x-\beta_2y)\dots};$$

and now expanding the right-hand side

$$h_{pq}=\sum\binom{p_1+q_1}{p_1}\binom{p_2+q_2}{p_2}\dots(\overline{p_1q_1}\,\overline{p_2q_2}\dots),$$

the summation being for all partitions of the biweight. Further writing

$$1+h_{10}x+h_{01}y+\dots+h_{pq}x^py^q+\dots$$
$$=\frac{1}{1-a_{10}x-a_{01}y+\dots+(-)^{p+q}a_{pq}x^py^q+\dots},$$

we find that the effect of changing the signs of both x and y is merely to interchange the symbols a and h; hence in any relation connecting the quantities h_{pq} with the quantities a_{pq} we are at liberty to interchange the symbols a and h. By the exponential and multinomial theorems we obtain the results—

$$(-)^{p+q-2}h_{pq}=\sum_\pi(-)^{\Sigma\pi-1}\frac{(\Sigma\pi)!}{\pi_1!\,\pi_2!\dots}a_{p_1q_1}^{\pi_1}a_{p_2q_2}^{\pi_2}\dots$$

and in this a and h are interchangeable.

$$\frac{(p+q-1)!}{p!\,q!}s_{pq}=\sum_\pi(-)^{\Sigma\pi-1}\frac{(\Sigma\pi-1)!}{\pi_1!\,\pi_2!\dots}h_{p_1q_1}^{\pi_1}h_{p_2q_2}^{\pi_2}\dots;$$

$$h_{pq}=\sum\left\{\frac{(p_1+q_1-1)!}{p_1!\,q_1!}\right\}^{\pi_1}\left\{\frac{(p_2+q_2-1)!}{p_2!\,q_2!\dots}\right\}^{\pi_2}\dots\frac{1}{\pi_1!\,\pi_2!\dots}s_{p_1q_1}^{\pi_1}s_{p_2q_2}^{\pi_2}\dots$$

Differential Operations.—If, in the identity

$$(1+\alpha_1x+\beta_1y)(1+\alpha_2x+\beta_2y)\dots(1+\alpha_nx+\beta_ny)$$
$$=1+a_{10}x+a_{01}y+a_{20}x^2+a_{11}xy+a_{02}y^2+\dots,$$

we multiply each side by $(1+\mu x+\nu y)$, the right-hand side becomes

$$1+(a_{10}+\mu)x+(a_{01}+\nu)y+\dots+(a_{pq}+\mu a_{p-1,q}+\nu a_{p,q-1})x^py^q+\dots;$$

hence any rational integral function of the coefficients $a_{10}, a_{01}, \dots a_{pq}, \dots$ say $f(a_{10}, a_{01}, \dots)\equiv f$ is converted into

$$\overline{exp}(\mu d_{10}+\nu d_{01})f$$

$$\text{where } d_{10}=\sum a_{p-1,q}\frac{d}{da_{pq}},\ d_{01}=\sum a_{p,q-1}\frac{d}{da_{pq}}.$$

The rule over exp will serve to denote that $\mu d_{10}+\nu d_{01}$ is to be raised to the various powers symbolically as in Taylor's theorem.

Writing
$$D_{pq}=\frac{1}{p!\,q!}d_{10}^pd_{01}^q,$$

$$\overline{exp}(\mu d_{10}+\nu d_{01})=(1+\mu D_{10}+\nu D_{01}+\dots+\mu^p\nu^qD_{pq}+\dots)f;$$

now, since the introduction of the new quantities μ, ν results in the addition to the function $(\overline{p_1q_1}\,\overline{p_2q_2}\,\overline{p_3q_3}\dots)$ of the new terms

$$\mu^{p_1}\nu^{q_1}(\overline{p_2q_2}\,\overline{p_3q_3}\dots)+\mu^{p_2}\nu^{q_2}(\overline{p_1q_1}\,\overline{p_3q_3}\dots)+\mu^{p_3}\nu^{q_3}(\overline{p_1q_1}\,\overline{p_2q_2}\dots)+\dots,$$

we find

$$D_{p_1q_1}(\overline{p_1q_1}\,\overline{p_2q_2}\,\overline{p_3q_3}\dots)=(\overline{p_2q_2}\,\overline{p_3q_3}\dots);$$

and thence

$$D_{p_1q_1}D_{p_2q_2}D_{p_3q_3}\dots(\overline{p_1q_1}\,\overline{p_2q_2}\,\overline{p_3q_3}\dots)=1;$$

while $D_{rs}f=0$ unless the part $\overline{rs}$ is involved in f. We may then state that D_{pq} is an operation which obliterates one part $\overline{pq}$ when such part is present, but in the contrary case causes the function to vanish. From the above D_{pq} is an operator of order pq, but it is convenient for some purposes to obtain its expression in the form of a number of terms, each of which denotes pq successive linear operations; to accomplish this write

$$d_{pq}=\sum a_{rs}\frac{d}{a_{p+r,q+s}}$$

and note the general result.[†]

$$\overline{exp}\ (m_{10}d_{10}+m_{01}d_{01}+\dots+m_{pq}d_{pq}+\dots)$$
$$=exp\ (M_{10}d_{10}+M_{01}d_{01}+\dots+M_{pq}d_{pq}+\dots);$$

where the multiplications on the left- and right-hand sides of the equation are symbolic and unsymbolic respectively, provided that m_{pq}, M_{pq} are quantities which satisfy the relation

---

[*] Vienna *Transactions*, t. iv. 1852.

[†] *Phil. Trans. R. S. London*, 1890, p. 490.

$$\begin{aligned}&exp\,(M_{10}\xi+M_{01}\eta+\ldots+M_{pq}\xi^p\eta^q+\ldots)\\&=1+m_{10}\xi+m_{01}\eta+\ldots+m_{pq}\xi^p\eta^q+\ldots;\end{aligned}$$

where ξ, η are undetermined algebraic quantities. In the present particular case putting $m_{10}=\mu$, $m_{01}=\nu$ and $m_{pq}=0$ otherwise

$$M_{10}\xi+M_{01}\eta+\ldots+M_{pq}\xi^p\eta^q+\ldots=\log\,(1+\mu\xi+\nu\eta)$$

or

$$M_{pq}=(-)^{p+q-1}\frac{(p+q-1)!}{p!\,q!}\mu^p\nu^q;$$

and the result is thus

$$\begin{aligned}&\overline{exp}(\mu d_{10}+\nu d_{01})\\&=exp\left\{\mu d_{10}+\nu d_{01}-\frac{1}{2}(\mu^2d_{20}+2\mu\nu d_{11}+\nu^2d_{02})+\ldots\right\}\\&=1+\mu D_{10}+\nu D_{01}+\ldots+\mu^p\nu^qD_{pq}+\ldots;\end{aligned}$$

and thence

$$\begin{aligned}&\mu d_{10}+\nu d_{01}-\frac{1}{2}(\mu^2d_{20}+2\mu\nu d_{11}+\nu^2d_{02})+\ldots\\&=\log\,(1+\mu D_{10}+\nu D_{01}+\ldots+\mu^p\nu^qD_{pq}+\ldots).\end{aligned}$$

From these formulæ we derive two important relations, viz. :—

$$(-)^{p+q-1}\frac{(p+q-1)!}{p!\,q!}d_{pq}=\sum_\pi(-)^{\Sigma\pi-1}\frac{(\Sigma\pi-1)!}{\pi_1!\,\pi_2!\ldots}D^{\pi_1}_{p_1q_1}D^{\pi_2}_{p_2q_2}\ldots,$$

$$(-)^{p+q-1}D_{pq}=\sum_\pi\left\{\frac{(p_1+q_1-1)!}{p_1!\,q_1!}\right\}^{\pi_1}\left\{\frac{(p_2+q_2-1)!}{p_2!\,q_2!}\right\}^{\pi_2}\ldots\quad\ldots\frac{(-)^{\Sigma\pi-1}}{\pi_1!\,\pi_2!\ldots}d^{\pi_1}_{p_1q_1}d^{\pi_2}_{p_2q_2}\ldots,$$

the last written relation having, in regard to each term on the right-hand side, to do with $\Sigma\pi$ successive linear operations. Recalling the formulæ above which connect s_{pq} and a_{pq}, we see that d_{pq} and D_{pq} are in corelation with these quantities respectively, and may be said to be operations which correspond to the partitions (pq), $(\overline{10}^p\,\overline{01}^q)$ respectively. We might conjecture from this observation that every partition is in correspondence with some operation; this is found to be the case, and it has been shown (*loc. cit.* p. 493) that the operation

$$\frac{1}{\pi_1!}\frac{1}{\pi_2!}\cdots d^{\pi_1}_{p_1q_1}d^{\pi_2}_{p_2q_2}\cdots\quad\text{(multiplication symbolic)}$$

corresponds to the partition $(\overline{p_1q_1}^{\pi_1}\,\overline{p_2q_2}^{\pi_2}\ldots)$. The partitions being taken as denoting symmetric functions we have complete correspondence between the algebras of quantity and operation, and from any algebraic formula we can at once write down an operation formula. This fact is of extreme importance in the theory of algebraic forms, and is easily representable whatever be the number of the systems of quantities.

We may remark the particular result

$$(-)^{p+q-1}\frac{(p+q-1)!}{p!\,q!}d_{pq}s_{pq}=D_{pq}(\overline{pq})=1;$$

d_{pq} causes every other single part function to vanish, and must cause any monomial function to vanish which does not comprise one of the partitions of the biweight $\overline{pq}$ amongst its parts.

Since

$$d_{pq}=(-)^{p+q-1}\frac{(p+q-1)!}{p!\,q!}\frac{d}{ds_{pq}},$$

the solutions of the partial differential equation $d_{pq}=0$ are the single bipart forms, omitting s_{pq}, and we have seen that the solutions of $D_{pq}=0$ are those monomial functions in which the part $\overline{pq}$ is absent.

One more relation is easily obtained, viz. :—

$$\frac{d}{da_{pq}}=d_{pq}-h_{10}d_{p+1,q}-h_{01}d_{p,q+1}+\ldots+(-)^{r+s}h_{rs}d_{p+r,q+s}+\ldots.$$

Theory of Three Identities.—Let

$$\begin{aligned}&1+a_{10}x+a_{01}y+\ldots+a_{pq}x^py^q+\ldots&&\text{(I.)}\\&\quad=(1+\alpha_1x+\beta_1y)(1+\alpha_2x+\beta_2y)\ldots\\&1+b_{10}x+b_{01}y+\ldots+b_{pq}x^py^q+\ldots\\&\quad=(1+\alpha^{(1)}_1x+\beta^{(1)}_1y)(1+\alpha^{(1)}_2x+\beta^{(1)}_2y)\ldots&&\text{(II.)}\\&1+c_{10}x+c_{01}y+\ldots+c_{pq}x^py^q+\ldots\\&\quad=(1+\alpha^{(2)}_1x+\beta^{(2)}_1y)(1+\alpha^{(2)}_2x+\beta^{(2)}_2y)\ldots&&\text{(III.)}\end{aligned}$$

wherein x and y are to be regarded as undeterminal quantities, and the identities as merely expressing relations between the coefficients on the left and the quantities α, β on the right. Assume the coefficients and quantities in the identities I. and II. to be given, and the coefficients in III. to be then determined by

$$\begin{aligned}&1+c_{10}\xi+c_{01}\eta+\ldots+c_{pq}\xi^p\eta^q+\ldots\\&=\prod_s(1+\alpha_sb_{10}\xi+\beta_sb_{01}\eta+\ldots+\alpha_s^p\beta_s^qb_{pq}\xi^p\eta^q+\ldots),\end{aligned}$$

ξ and η being undetermined quantities.

This assumes that the coefficients c_{pq} of III. are certain functions of the quantities and coefficients of I. and II. Denoting symmetric functions of the quantities in I., II., and III. by partitions in brackets $(\;)$, $(\;)_1$, $(\;)_2$ respectively, we find that the assumed relation gives—

$$\begin{aligned}&c_{10}=(\overline{10})b_{10},\\&c_{01}=(\overline{01})b_{01},\\&c_{20}=(\overline{20})b_{20}+(\overline{10}^2)b_{10}^2,\\&c_{11}=(\overline{11})b_{11}+(\overline{10}\,\overline{01})b_{10}b_{01},\\&c_{21}=(\overline{21})b_{21}+(\overline{20}\,\overline{01})b_{20}b_{01}+(\overline{11}\,\overline{10})b_{11}b_{10}+(\overline{10}^2\,\overline{01})b_{10}^2b_{01},\\&\quad\text{\&c.}\quad.\quad.\quad.\quad.\quad.\quad.\quad.\end{aligned}$$

and generally, in the expression of c_{pq}, every symmetric function of biweight $\overline{pq}$ of the quantities in I. occurs, each attached to the corresponding product of coefficients from the second identity. Now

$$\prod_s(1+\alpha_sb_{10}\xi+\beta_sb_{01}\eta+\ldots+\alpha_s^p\beta_s^qb_{pq}\xi^p\eta^q+\ldots)$$

is from II. equal to

$$\prod_s\prod_t\{1+\alpha_s\alpha^{(1)}_t\xi+\beta_s\beta^{(1)}_t\eta\},$$

as can be seen by putting $x=\alpha_s\xi$, $y=\beta_s\eta$. Hence, from the assumed relation and III.,

$$\sum_s\log\,\{1+\alpha^{(2)}_s\xi+\beta^{(2)}_s\eta\}=\sum_s\sum_t\log\,\{1+\alpha_s\alpha^{(1)}_t\xi+\beta_s\beta^{(1)}_t\eta\};$$

and now, expanding and equating coefficients of $\xi^p\eta^q$,

$$(\overline{pq})_2=(\overline{pq})(\overline{pq})_1,$$

a simple and important consequence of the assumed relation. It shows that the relation in question is unaltered by interchange of the quantities in I. and II. in such wise that α_s and $\alpha^{(1)}_s$ and also β_s and $\beta^{(1)}_s$ are transposed.

Let the operations d_{pq}, D_{pq} refer to I., and the corresponding operations of II. and III. be denoted by the same symbols with the addition of single and double dashes respectively. Write the assumed relation in the abbreviated form

$$U=u_{\alpha_1\beta_1}u_{\alpha_2\beta_2}u_{\alpha_3\beta_3}\ldots,$$

then

$$d'_{pq}U=(d'_{pq}u_{\alpha_1\beta_1})u_{\alpha_2\beta_2}u_{\alpha_3\beta_3}\ldots+\ldots,$$

and

$$d'_{pq}=\frac{d}{db_{pq}}+b_{10}\frac{d}{db_{p+1,q}}+b_{01}\frac{d}{db_{p,q+1}}+\ldots$$

when performed upon $u_{\alpha_s\beta_s}$ gives

$$d'_{pq}u_{\alpha_s\beta_s}=\alpha_s^p\beta_s^q\xi^p\eta^qu_{\alpha_s\beta_s};$$

hence

$$d'_{pq}U=(\overline{pq})\xi^p\eta^qU,$$

and, replacing U by its expression,

$$d'_{pq}c_{pq}=(\overline{pq}),\ \text{and in general}$$

$$d'_{pq}c_{rs}=(\overline{pq})c_{r-p,s-q};$$

whence, regarding the coefficients b_{pq} as functions of the coefficients c_{pq} only,

$$d'_{pq}=\Sigma(d'_{pq}c_{rs})\frac{d}{dc_{rs}}=(\overline{pq})d''_{pq}.$$

In a precisely similar manner $d_{pq}=(\overline{pq})_1d''_{pq}$, and making use of the established relation $(\overline{pq})_2=(\overline{pq})(\overline{pq})_1$,

$$(\overline{pq})_2d''_{pq}=(\overline{pq})_1d'_{pq}=(\overline{pq})d_{pq}.$$

As a consequence of this, if we regard the assumed relation as defining a transformation of the quantities in III. into either of the sets of quantities occurring in I. and II., the operation $(pq)_2d''_{pq}$ is an invariant. We can now derive relations between the operations D_{pq}, D'_{pq}, D''_{pq}. For

$$\begin{aligned}&\xi d'_{10}+\eta d'_{01}-\frac{1}{2}(\xi^2d'_{20}+2\xi\eta d'_{11}+\eta^2d'_{02})+\ldots\\&=\xi(\overline{10})d''_{10}+\eta(\overline{01})d''_{01}-\frac{1}{2}\left\{\xi^2(\overline{20})d''_{20}+2\xi\eta(\overline{11})d''_{11}+\eta^2(\overline{02})d''_{02}\right\}+\ldots,\end{aligned}$$

and this leads to

$$\begin{aligned}&\log\,(1+\xi D'_{10}+\eta D'_{01}+\ldots+\xi^p\eta^qD'_{pq}+\ldots)\\&=\Sigma\log\,(1+\xi\alpha_sD''_{10}+\eta\beta_sD''_{01}+\ldots+\xi^p\eta^q\alpha_s^p\beta_s^qD''_{pq}+\ldots);\end{aligned}$$

and thus to

$$\begin{aligned}&1+\xi D'_{10}+\eta D'_{01}+\ldots+\xi^p\eta^qD'_{pq}+\ldots\\&=\prod_s(1+\xi\alpha_sD''_{10}+\eta\beta_sD''_{01}+\ldots+\xi^p\eta^q\alpha_s^p\beta_s^qD''_{pq}+\ldots);\end{aligned}$$

and this, when compared with the assumed relation, establishes that in any formula connecting the coefficients c_{pq} and b_{pq}, we are at liberty to substitute D'_{pq} for c_{pq} and D''_{pq} for b_{pq}; we thus obtain a corresponding operator relation; further, it is similarly proved that, in any relation connecting the quantities c_{pq} and a_{pq}, we may substitute D_{pq} for c_{pq} and D''_{pq} for a_{pq}.

First Law of Symmetry.—We are now in a position to establish certain laws of symmetry which appertain to the systems of algebraic forms under consideration. The relation $(\overline{pq})_2=(\overline{pq})_1(pq)$ shows that any symmetric function in brackets $(\ )_2$ may be expressed as a linear function of products, each of which is a function $(\ )_1$ multiplied by a function $(\ )$, and that, moreover, such expression is symmetrical in regard to the brackets $(\ )_1$ and $(\ )$.

Hence we may write

$$\begin{aligned}&(\overline{r_1s_1}^{\rho_1}\overline{r_2s_2}^{\rho_2}\ldots)_2\\ &=\ldots+\mathrm{J}(\overline{a_1b_1}^{\alpha_1}\overline{a_2b_2}^{\alpha_2}\ldots)_1(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)\\ &\quad+\mathrm{J}(\overline{a_1b_1}^{\alpha_1}\overline{a_2b_2}^{\alpha_2}\ldots)(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2})_1+\ldots \qquad \text{(A)}\end{aligned}$$

Moreover, any product of the coefficients c_{pq} can be expressed as a linear function of terms, each of which contains a monomial function of the quantities $a_1, \beta_1, a_2, \beta_2, \ldots$ and a product of coefficients b_{pq}, so that we may assume

$$c^{\pi_1}_{p_1q_1}c^{\pi_2}_{p_2q_2}\ldots=\ldots+\mathrm{L}(\overline{a_1b_1}^{\alpha_1}\overline{a_2b_2}^{\alpha_2}\ldots)b^{\rho_1}_{r_1s_1}b^{\rho_2}_{r_2s_2}\ldots+\ldots \qquad \text{(B)}$$

$$c^{\alpha_1}_{a_1b_1}c^{\alpha_2}_{a_2b_2}\ldots=\ldots+\mathrm{M}(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)b^{\rho_1}_{r_1s_1}b^{\rho_2}_{r_2s_2}\ldots+\ldots \qquad \text{(C)}$$

and it will appear that $\mathrm{L}=\mathrm{M}$; for from (B) can be derived the operator relation

$$D'^{\pi_1}_{p_1q_1}D'^{\pi_2}_{p_2q_2}\ldots=\ldots+\mathrm{L}(\overline{a_1b_1}^{\alpha_1}\overline{a_2b_2}^{\alpha_2}\ldots)D''^{\rho_1}_{r_1s_1}D''^{\rho_2}_{r_2s_2}\ldots+\ldots,$$

and performing each side of this equation upon the opposite side of equation (A) we obtain, after cancelling $(\overline{a_1b_1}^{\alpha_1}\overline{a_2b_2}^{\alpha_2}\ldots)$,

$$\mathrm{L}D''^{\rho_1}_{r_1s_1}D''^{\rho_2}_{r_2s_2}\ldots(\overline{r_1s_1}^{\rho_1}\overline{r_2s_2}^{\rho_2}\ldots)_2=\mathrm{J}D'^{\pi_1}_{p_1q_1}D'^{\pi_2}_{p_2q_2}\ldots(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)_1$$

or

$$\mathrm{L}=\mathrm{J}.$$

By a similar process, in which equation (C) replaces (B), we find $\mathrm{M}=\mathrm{J}$ and hence $\mathrm{L}=\mathrm{M}$ and the equations (B) and (C) indicate with $\mathrm{L}=\mathrm{M}$ a law of symmetry. We may say that in (B) the interchange of the partitions $(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$, $(\overline{a_1b_1}^{\alpha_1}\overline{a_2b_2}^{\alpha_2}\ldots)$ leaves the number L unchanged. To explain the nature of the theorem that has been established, recourse must be had to the notion of a separation of a partition of given specification; the definitions of these terms have been given above in respect of a single system of quantities and the analogous definitions, in respect of several systems, will be easily understood without further remarks. Writing the relation (B) in the form

$$c^{\pi_1}_{p_1q_1}c^{\pi_2}_{p_2q_2}\ldots=\ldots+\mathrm{P}b^{\rho_1}_{r_1s_1}b^{\rho_1}_{r_2s_2}\ldots+\ldots$$

where P denotes the complete cofactor of $b^{\rho_1}_{r_1s_1}b^{\rho_2}_{r_2s_2}\ldots$ we may state that P is a linear function of symmetric function products each of which is a separation of

$$(\overline{r_1s_1}^{\rho_1}\overline{r_2s_2}^{\rho_2}\ldots),$$

and has a specification

$$(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots).$$

This appears at once by actually forming the product $c^{\pi_1}_{p_1q_1}c^{\pi_2}_{p_2q_2}\ldots$ from the separate expressions of $c_{p_1q_1}, c_{p_2q_2}, \ldots$ Let $\theta_1, \theta_2, \ldots \theta_k$ be the different specifications which appertain to the separations of $\overline{r_1s_1}^{\rho_1}\overline{r_2s_2}^{\rho_2}\ldots)$ and let P_θ denote the symmetric function product, of specification θ, above alluded to. It may be seen that when $\mathrm{P}_{\theta_1}, \mathrm{P}_{\theta_2}, \ldots \mathrm{P}_{\theta_k}$ are multiplied out, so as to be exhibited as a linear function of monomial functions, the partitions of the latter are all drawn from the series $\theta_1, \theta_2, \ldots \theta_k$ and we may write

$$\begin{aligned}\mathrm{P}_{\theta_1}&=m_{11}\theta_1+m_{12}\theta_2+\ldots+m_{1k}\theta_k,\\ \mathrm{P}_{\theta_2}&=m_{21}\theta_1+m_{22}\theta_2+\ldots+m_{2k}\theta_k,\\ &\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\\ \mathrm{P}_{\theta_k}&=m_{k1}\theta_1+m_{k2}\theta_2+\ldots+m_{kk}\theta_k,\end{aligned}$$

the quantities m being numbers.

The law of symmetry, that has been found, may now be stated in the form

$$m_{rs}=m_{sr};$$

viz., the determinant of the above relations is symmetrical. We may say, in regard to any monomial function $(\overline{r_1s_1}^{\rho_1}\overline{r_2s_2}^{\rho_2}\ldots)$, that if $\theta_1, \theta_2, \ldots \theta_k$ be the monomial functions, whose partitions are the specifications of the various separations, the coefficients of the monomial θ_s, in the development of the assemblage of separations P_{θ_r}, is equal to the coefficients of the monomial θ_r in the development of P_{θ_s}.

By solving k linear equations we obtain

$$\begin{aligned}\theta_1&=\mu_{11}\mathrm{P}_{\theta_1}+\mu_{12}\mathrm{P}_{\theta_2}+\ldots+\mu_{1k}\mathrm{P}_{\theta_k},\\ \theta_2&=\mu_{21}\mathrm{P}_{\theta_1}+\mu_{22}\mathrm{P}_{\theta_2}+\ldots+\mu_{2k}\mathrm{P}_{\theta_k},\\ \theta_k&=\mu_{k1}\mathrm{P}_{\theta_1}+\mu_{k2}\mathrm{P}_{\theta_2}+\ldots+\mu_{kk}\mathrm{P}_{\theta_k},\end{aligned}$$

and the determinant of this system is also symmetrical since $\mu_{rs}=\mu_{sr}$ is a necessary consequence of $m_{sr}=m_{rs}$. We can evidently form two symmetrical tables in connexion with every partition of a multipartite number.

The last system of equations involves an important theory of expressibility; for any one of the monomial functions θ is expressed by a partition which is the specification of some separation of

$$(\overline{r_1s_1}^{\rho_1}\overline{r_2s_2}^{\rho_2}\ldots),$$

and this implies that the parts of the partition of θ can be partitioned into parts the aggregate of which is identical with the parts of $(\overline{r_1s_1}^{\rho_1}\overline{r_2s_2}^{\rho_2}\ldots)$. Hence the *theorem of expressibility*. "If the parts of the partition of a monomial function θ be partitioned in *any manner* into parts, which when all assembled in a single bracket are represented by $(\overline{r_1s_1}^{\rho_1}\overline{r_2s_2}^{\rho_2}\ldots)$, the symmetric function θ is expressible as a linear function of assemblages of separations of the function

$$(\overline{r_1s_1}^{\rho_1}\overline{r_2s_2}^{\rho_2}\ldots)."$$

We may write the relation $(pq)_2=(\overline{pq})(\overline{pq})_1$ in the form:—

$$\sum_\pi(-)^{\Sigma\pi-1}\frac{(\Sigma\pi-1)!}{\pi_1!\pi_2!\ldots}c^{\pi_1}_{p_1q_1}c^{\pi_2}_{p_2q_2}\ldots$$

$$=(\overline{pq})\sum_\pi(-)^{\Sigma\pi-1}\frac{(\Sigma\pi-1)!}{\pi_1!\pi_2!\ldots}b^{\pi_1}_{p_1q_1}b^{\pi_2}_{p_2q_2}\ldots$$

If we express the quantities c_{pq} in terms of the quantities b_{pq} and $a_1, \beta_1, a_2, \beta_2$, &c., the symmetric function products which multiply $b^{\pi_1}_{p_1q_1}b^{\pi_1}_{p_2q_2}\ldots$ on the left will be, all of them, necessarily separations of $(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$, and the result of comparing the cofactors of $b^{\pi_1}_{p_1q_1}b^{\pi_2}_{p_2q_2}\ldots$, on the two sides, will be the expression of (pq) by means of separations of $(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$. Let

$$(\mathrm{J}_1)^{j_1}(\mathrm{J}_2)^{j_2}\ldots$$

be any separation of a given partition of $(\overline{pq})$; the comparison yields the result

$$(-)^{\Sigma\pi-1}\frac{(\Sigma\pi-1)!}{\pi_1!\pi_2!\ldots}(\overline{pq})=\sum(-)^{\Sigma j-1}\frac{(\Sigma j-1)!}{j_1!j_2!\ldots}(\mathrm{J}_1)^{j_1}(\mathrm{J}_2)^{j_2}\ldots,$$

the summation, on the right, having reference to every separation of the given partition of $(\overline{pq})$. This result, when applied to one part symmetric functions of n systems of quantities, is the furthest generalization of Waring's formula connected with sums of powers that has yet been made. The inverse formula, for the expression of any monomial function by means of one-part functions, may be written

$$(-)^{\Sigma\pi-1}(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$$

$$=\sum(-)^{\Sigma j-1}\frac{(\Sigma\pi_1-1)!(\Sigma\pi_2-1)!\ldots}{j_1!j_2!\ldots\pi_{11}!\pi_{12}!\ldots\pi_{21}!\pi_{22}!\ldots}s^{j_1}_{J_1}s^{j_2}_{J_2}\ldots,$$

where

$$(\mathrm{J}_1)^{j_1}(\mathrm{J}_2)^{j_2}\ldots=(\overline{p_{11}q_{11}}^{\pi_{11}}\overline{p_{12}q_{12}}^{\pi_{12}}\ldots)^{j_1}(\overline{p_{21}q_{21}}^{\pi_{21}}\overline{p_{22}q_{22}}^{\pi_{22}}\ldots)^{j_2}\ldots$$

is any separation of $(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_1}\ldots)$, the summation is in respect of all such separations, and s_J denotes the one part function of the same weight as the monomial (J).

Second Law of Symmetry.—The operation $\frac{1}{\pi_1!\pi_2!\ldots}d^{\pi_1}_{p_1q_1}d^{\pi_2}_{p_2q_2}\ldots$, the multiplication of linear operations being symbolic, and $(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$ being a partition of $(\overline{pq})$, may be said to have the weight pq; if the operand be of the same weight the operator is clearly equivalent to

$$\frac{1}{\pi_1!\pi_2!\ldots}\left(\frac{d}{da_{p_1q_1}}\right)^{\pi_1}\left(\frac{d}{da_{p_2q_2}}\right)^{\pi_2}\ldots$$

and thence

$$\frac{1}{\pi_1!\pi_2!\ldots}d^{\pi_1}_{p_1q_1}d^{\pi_2}_{p_2q_2}\ldots a^{\pi_1}_{p_1q_1}a^{\pi_2}_{p_2q_2}\ldots=1.$$

Now, from the three identities I., II., and III., we have

$$(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)_2=\ldots+\mathrm{P}b^{\rho_1}_{r_1s_1}b_{r_2s_2}\ldots+\ldots,$$

and the corresponding operator relation

$$\frac{1}{\pi_1!\,\pi_2!\dots}d_{p_1q_1}^{\pi_1}d_{p_2q_2}^{\pi_2}\dots=\dots+\mathrm{P}\mathrm{D}_{r_1s_1}^{\rho_1}\mathrm{D}_{r_2s_2}^{\rho_2}\dots+\dots;$$

where P consists entirely of symmetric functions of the quantities appertaining to the first identity. Assuming now a relation

$$(\overline{r_1s_1}^{\rho_1}\,\overline{r_2s_2}^{\rho_2}\dots)_2=\dots+\mathrm{Q}b_{p_1q_1}^{\pi_1}b_{p_2q_2}^{\pi_2}\dots+\dots,$$

and employing upon its left-hand side the right-hand side of the operator relation and *vice versâ*, we obtain the result $\mathrm{P}=\mathrm{Q}$, showing that, in the relation

$$(\overline{p_1q_1}^{\pi_1}\,\overline{p_2q_2}^{\pi_2}\dots)_2=\dots+\mathrm{P}b_{r_1s_1}^{\rho_1}b_{r_2s_2}^{\rho_2}\dots+\dots,$$

we are at liberty to interchange the partitions

$$(\overline{p_1q_1}^{\pi_1}\,\overline{p_2q_2}^{\pi_2}\dots)\text{ and }(\overline{r_1s_1}^{\rho_1}\,\overline{r_2s_2}^{\rho_2}\dots).$$

Third Law of Symmetry.—From the relation

$$c_{p_1q_1}^{\pi_1}c_{p_2q_2}^{\pi_2}\dots=\dots+\mathrm{L}b_{r_1s_1}^{\rho_1}b_{r_2s_2}^{\rho_2}\dots+\dots,$$

to which corresponds

$$\mathrm{D}_{p_1q_1}^{\pi_1}\mathrm{D}_{p_2q_2}^{\pi_2}\dots=\dots+\mathrm{L}\mathrm{D}_{r_1s_1}^{\rho_1}\mathrm{D}_{r_2s_2}^{\rho_2}\dots+\dots,$$

we obtain by the usual process

$$(\overline{r_1s_1}^{\rho_1}\,\overline{r_2s_2}^{\rho_2}\dots)=\dots+\mathrm{L}(\overline{p_1q_1}^{\pi_1}\,\overline{p_2q_2}^{\pi_2}\dots)+\dots;$$

involving an interesting law of reciprocity which has been discussed in the Memoirs referred to.

Linear Separation Operations.—A monomial function is expressible as a linear function of separations of any one of the partitions obtained by partitionment of its parts (see *ante*). In particular the partition $(\overline{10}^p\,\overline{01}^q)$ can be thus obtained, from any monomial of weight pq, and thence we find that the latter is expressible in terms of the elementary functions, since every product of these, of weight pq, is in fact a separation of $(\overline{10}^p\,\overline{01}^q)$. The linear operations d_{pq}, as above defined, are suited to operate upon such expressions, but are not at present adapted to operands associated with a separable partition other than $(\overline{10}^p\,\overline{01}^q)$. Let the separable partition be

$$(\overline{p_1q_1}^{\pi_1}\,\overline{p_2q_2}^{\pi_2}\dots);$$

and of this let any separation be

$$(\mathrm{J}_1)^{j_1}(\mathrm{J}_2)^{j_2}\dots,$$

(J_1), (J_2),...being the distinct factors that may occur. Then $d_{rs}=\Sigma d_{rs}(\mathrm{J})\frac{d}{d(\mathrm{J})}$, the summation being for all the factors (J) that may present themselves.

Let the general expression of (J) be

$$(\overline{10}^{\rho_{10}+\sigma_{10}}\,\overline{01}^{\rho_{01}+\sigma_{01}}\dots\overline{r_1s_1}^{\rho_{r_1s_1}+\sigma_{r_1s_1}}\dots);$$

then, since

$$(-)^{r+s-1}\frac{(r+s-1)!}{r!\,s!}d_{rs}$$

$$=\sum(-)^{\Sigma\rho-1}\frac{(\Sigma\rho-1)!}{\rho_{10}!\,\rho_{01}!\dots\rho_{r_1s_1}!\dots}\mathrm{D}_{10}^{\rho_{10}}\mathrm{D}_{01}^{\rho_{01}}\dots\mathrm{D}_{r_1s_1}^{\rho_{r_1s_1}}\dots,$$

we obtain

$$(-)^{r+s-1}\frac{(r+s-1)!}{r!\,s!}d_{rs}$$

$$=\sum_\rho\sum_\sigma(-)^{\Sigma\rho-1}\frac{(\Sigma\rho-1)!}{\rho_{10}!\,\rho_{01}!\dots\rho_{r_1s_1}!\dots}(\overline{10}^{\sigma_{10}}\,\overline{01}^{\sigma_{01}}\dots\overline{r_1s_1}^{\sigma_{r_1s_1}}\dots)\frac{d}{d(\mathrm{J})},$$

the summation being in regard to every distinct factor (J) that may present itself in a separation of the given separable partition, and to every partition $(\overline{10}^{\rho_{10}}\overline{01}^{\rho_{01}}\dots)$ of the weight rs of the given linear operator d_{rs}.

Regarding ρ_{10}, ρ_{01},...as constant write

$$\sum_\sigma(\overline{10}^{\sigma_{10}}\,\overline{01}^{\sigma_{01}}\dots\overline{r_1s_1}^{\sigma_{r_1s_1}}\dots)\frac{d}{d(\mathrm{J})}=d(\overline{10}^{\rho_{10}}\,\overline{01}^{\rho_{01}}\dots\overline{r_1s_1}^{\rho_{r_1s_1}}\dots),$$

and the operator relation becomes

$$(-)^{r+s-1}\frac{(r+s-1)!}{r!\,s!}d_{rs}$$

$$=\sum_\rho\frac{(-)^{\Sigma\rho-1}(\Sigma\rho-1)!}{\rho_{10}!\,\rho_{01}!\dots\rho_{r_1s_1}!\dots}d(\overline{10}^{\rho_{10}}\,\overline{01}^{\rho_{01}}\dots\overline{r_1s_1}^{\rho_{r_1s_1}}\dots),$$

the summation now being in regard to every partition $(\overline{10}^{\rho_{10}}\,\overline{01}^{\rho_{01}}\dots)$ of the weight rs. Observe that d_{rs} is a linear weight operator; that $d(\overline{10}^{\rho_{10}}\,\overline{01}^{\rho_{01}}\dots)$ is a linear partition operator; and that we have expressed the weight operator as a linear function of the partition operators of the same weight. Compare

(i.) the expression of d_{pq} in terms of the operations D_{pq};

(ii.) the expression of $(\overline{pq})$ by means of elementary functions.

It will be seen that the same law obtains.

Ex. gr. $d_{11}=d(\overline{10}\,\overline{01})-d(\overline{11})$

$$d_{21}=d(\overline{10}^2\,\overline{01})-d(\overline{20}\,\overline{01})-d(\overline{11}\,\overline{10})+d(\overline{21}),$$

are examples of the expressions of weight linear operators in terms of partition linear operators. The latter have developed expressions such as

$$d(\overline{10})=\frac{d}{d(\overline{10})}+(\overline{10})\frac{d}{d(\overline{10}^2)}+(\overline{01})\frac{d}{d(\overline{10}\,\overline{01})}+(\overline{11})\frac{d}{d(\overline{11}\,\overline{10})}+\dots,$$

$$d(\overline{20}\,\overline{01})=\frac{d}{d(\overline{20}\,\overline{01})}+(\overline{10})\frac{d}{d(\overline{20}\,\overline{10}\,\overline{01})}+\dots.$$

The alternant ("Combination," "Zusammensetzung"), of any two partition linear operators vanishes, and, as a consequence, if $d(\mathrm{A})$, $d(\mathrm{B})$ be any two operators and ϕ a solution of $d(\mathrm{A})=0$, $d(\mathrm{B})\phi$ will also be a solution of the same equation. It has also been shown (*loc. cit.*) that if a function, expressed in terms of separations of a given monomial symmetric function, be caused to vanish by any weight operator, every partition operator of the same weight will also cause it to vanish. This is a cardinal theorem appertaining to the expression of any function by means of separations of a given partition.

Ex. gr. Suppose it requisite to express the function $(\overline{31}\,\overline{01})$ by means of separations of the function $(\overline{21}\,\overline{10}\,\overline{01})$; the "law of expressibility" (*ante*) shows this to be possible, because $(\overline{21}\,\overline{01})$ is a partition of $(\overline{31})$. Assume

$$(\overline{31}\,\overline{01})=\mathrm{A}(\overline{21}\,\overline{10})(\overline{01})+\mathrm{B}(\overline{21}\,\overline{01})(\overline{10})+\mathrm{C}(\overline{10}\,\overline{01})(\overline{21})+\mathrm{D}(\overline{21}\,\overline{10}\,\overline{01}),$$

since the terms $(\overline{21})(\overline{10})(\overline{01})$ clearly cannot present itself. d_{31}, d_{01}, d_{32} do not make $(\overline{31}\,\overline{01})$ vanish, because $(\overline{31}\,\overline{01})$ involves partitions of $\overline{31}$, $\overline{01}$, and $\overline{32}$; but every other weight operator makes it vanish. Selecting d_{10} and d_{21} we may make further selection of the partition operators $d(\overline{10})$ and $d(\overline{21})$. Operating then with

$$\frac{d}{d(\overline{10})}+(\overline{01})\frac{d}{d(\overline{10}\,\overline{01})}+(\overline{21})\frac{d}{d(\overline{21}\,\overline{10})}+(\overline{21}\,\overline{01})\frac{d}{d(\overline{21}\,\overline{10}\,\overline{01})},$$

and with

$$\frac{d}{d(\overline{21})}+(\overline{10})\frac{d}{d(\overline{21}\,\overline{10})}+(\overline{01})\frac{d}{d(\overline{21}\,\overline{01})}+(\overline{10}\,\overline{01})\frac{d}{d(\overline{21}\,\overline{10}\,\overline{01})},$$

we find $\mathrm{A}+\mathrm{C}=\mathrm{B}+\mathrm{D}=\mathrm{C}+\mathrm{D}=\mathrm{A}+\mathrm{B}=0$, and thence

$$(\overline{31}\,\overline{01})=\mathrm{A}\{(\overline{21}\,\overline{10})(\overline{01})-(\overline{21}\,\overline{01})(\overline{10})-(\overline{10}\,\overline{01})(\overline{21})+(\overline{21}\,\overline{10}\,\overline{01})\}.$$

There are many ways of showing that $\mathrm{A}=-\frac{1}{2}$; perhaps the most instructive is to make use of the relation $d_{21}=\dots-\mathrm{D}_{21}+\dots=\dots+d(\overline{21}\,\overline{10})+\dots$; and, performing $-\mathrm{D}_{21}$ and $d(\overline{21}\,\overline{10})$ on opposite sides,

$$-(\overline{01})=\mathrm{A}\{(\overline{01})+(\overline{01})\}\text{ or }\mathrm{A}=-\frac{1}{2}.$$

It has been seen that a generalization has been made from a weight operator d_{pq} to a partition operator. The same thing obtains with respect to the obliterating operator D_{pq}. In the case of a single system of quantities it was established that D_p is performed upon a product of monomial functions through its various partitions; we have, in fact, to pick out all partitions of p in all possible ways from the given product, taking one part only from each factor of the product; the component operation associated with the partition $(p_1^{\pi_1}p_2^{\pi_2}\dots)$ of p we may appropriately denote by

$$\mathrm{D}(p_1^{\pi_1}p_2^{\pi_2}\dots).$$

So similarly, in respect of several systems, we have the weight operator D_{pq} and the partition operator

$$\mathrm{D}(\overline{p_1q_1}^{\pi_1}\,\overline{p_2q_2}^{\pi_2}\dots);$$

and we have the equivalence

$$\mathrm{D}_{pq}=\Sigma\mathrm{D}(\overline{p_1q_1}^{\pi_1}\,\overline{p_2q_2}^{\pi_2}\dots)$$

the summation being for all partitions of the weight (*loc. cit.* § 10).

Ex. gr.: $\mathrm{D}_{10}=\mathrm{D}(\overline{10})$

$\mathrm{D}_{11}=\mathrm{D}(\overline{10}\,\overline{01})+\mathrm{D}(\overline{11})$.

The connexion between the weight operators d_{pq}, D_{pq} has been established; the corresponding relations between the partition operators are important. The analogy between quantity and operation must be kept in view; with this object denote by $s(\overline{p_1q_1}^{\pi_1}\,\overline{p_2q_2}^{\pi_2}\dots)$ the expression of s_{pq} by means of separations of $(\overline{p_1p_1}^{\pi_1}\,\overline{p_2q_2}^{\pi_2}\dots)$, and by S_{pq} the sum of all the monomial symmetric functions of weight pq. S_{pq} differs from h_{pq} as will be seen by recalling the definition of h_{pq}. From a previous result we may write

$$\sum_{\pi}\frac{(-)^{\Sigma\pi-1}(\Sigma\pi-1)!}{\pi_1!\pi_2!\ldots}s(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$$

$$=\sum_{\pi}\frac{(-)^{\Sigma\pi-1}(\Sigma\pi-1)!}{\pi_1!\pi_2!\ldots}S_{p_1q_1}^{\pi_1}S_{p_2q_2}^{\pi_2}\ldots$$

which must be compared with

$$\sum_{\pi}\frac{(-)^{\Sigma\pi-1}(\Sigma\pi-1)!}{\pi_1!\pi_2!\ldots}d(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$$

$$=\sum_{\pi}\frac{(-)^{\Sigma\pi-1}(\Sigma\pi-1)!}{\pi_1!\pi_2!\ldots}D_{p_1q_1}^{\pi_1}D_{p_2q_2}^{\pi_2}\ldots.$$

Now, just as $S_{pq}=\Sigma(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$,

so $D_{pq}=\Sigma D(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$,

and substituting for $S_{p_1q_1}$, $S_{p_2q_2}$, ... their partition expressions we obtain, from the quantity relation, the important formula

$$\frac{(-)^{\Sigma\pi-1}(\Sigma\pi-1)!}{\pi_1!\pi_2!\ldots}s(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$$

$$=\sum_{j}\frac{(-)^{\Sigma j-1}(\Sigma j-1)!}{j_1!j_2!\ldots}(J_1)^{j_1}(J_2)^{j_2}\ldots,$$

where $(J_1)^{j_1}(J_2)^{j_2}\ldots$ is a separation of $(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$; so in the operator relation, by substituting for the weight operators their expressions in terms of partition operators, we obtain the new formula,

$$\frac{(-)^{\Sigma\pi-1}(\Sigma\pi-1)!}{\pi_1!\pi_2!\ldots}d(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$$

$$=\sum_{j}\frac{(-)^{\Sigma j-1}(\Sigma j-1)!}{j_1!j_2!\ldots}D^{j_1}(J_1)D^{j_2}(J_2)\ldots,$$

$D(J_1)$, $D(J_2)$,... being partition D operators.

Reversing the two formulæ we obtain

$$(-)^{\Sigma\pi-1}(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$$

$$=\sum_{j}(-)^{\Sigma j-1}\frac{(\Sigma\pi_1-1)!(\Sigma\pi_2-1)!\ldots}{j_1!j_2!\ldots\pi_{11}!\pi_{12}!\ldots\pi_{21}!\pi_{22}!\ldots}s^{j_1}(J_1)s^{j_2}(J_2)\ldots;$$

$$(-)^{\Sigma\pi-1}D(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)$$

$$\sum_{j}(-)^{\Sigma j-1}\frac{(\Sigma\pi_1-1)!(\Sigma\pi_2-1)!\ldots}{j_1!j_2!\ldots\pi_{11}!\pi_{12}!\ldots\pi_{21}!\pi_{22}!\ldots}d^{j_1}(J_1)d^{j_2}(J_2)\ldots,$$

where $(J_1)=(\overline{p_{11}q_{11}}^{\pi_{11}}\overline{p_{12}q_{12}}^{\pi_{12}}\ldots)$, $(J_2)=(\overline{p_{21}q_{21}}^{\pi_{21}}\overline{p_{22}q_{22}}^{\pi_{22}}\ldots)$, &c.

We have thus complete correspondence between the algebras of quantity and differential operation.

Observe the particular results

$$D(\overline{p_1q_1}^{\pi_1}\overline{p_2q_2}^{\pi_2}\ldots)s_{p_1q_1}^{\pi_1}s_{p_2q_2}^{\pi_2}\ldots=1,$$

$$\frac{1}{j_1!j_2!\ldots}d^{j_1}(J_1)d^{j_2}(J_2)\ldots(J_1)^{j_1}(J_2)^{j_2}\ldots=1.$$

References for Symmetric Functions.—GIRARD. *Invention nouvelle en l'algèbre.* Amsterdam, 1629.—WARING. *Meditationes Algebraicæ.* London, 1782.—LAGRANGE. *Mém. de l'acad. de Berlin*, 1768.—MEYER-HIRSCH. *Sammlung von Aufgaben aus der Theorie der algebraischen Gleichungen.* Berlin, 1809.—SERRET. *Cours d'algèbre supérieure*, t. iii. Paris, 1885.—UNFERDINGER. *Sitzungsber. d. Acad. d. Wissensch. i. Wien.* Bd. lx. Vienna, 1869.—L. SCHLÄFLI. "Ueber die Resultante eines Systemes mehrerer algebraischen Gleichungen," *Vienna Transactions*, t. iv. 1852.—MACMAHON. "Memoirs on a New Theory of Symmetric Functions," *American Journal of Mathematics.* Baltimore, Md. 1888-90; "Memoir on Symmetric Functions of Roots of Systems of Equations," *Phil. Trans. R. S.* London, 1890.

III. THE THEORY OF BINARY FORMS.

A binary form of order n is a homogeneous polynomial of the *nth* degree in two variables. It may be written in the form

$$ax_1^n+bx_1^{n-1}x_2+cx_1^{n-2}x_2^2+\ldots;$$

or in the form

$$ax_1^n+\binom{n}{1}bx_1^{n-1}x_2+\binom{n}{2}cx_1^{n-2}x_2^2+\ldots,$$

which Cayley denotes by

$$(a, b, c, \ldots)(x_1, x_2)^n$$

$\binom{n}{1}$, $\binom{n}{2}$... being a notation for the successive binomial coefficients n, $\frac{1}{2}n(n-1)$,.... Other forms are

$$ax_1^n+nbx_1^{n-1}x_2+n(n-1)cx_1^{n-2}x_2^2+\ldots.$$

the binomial coefficients $\binom{n}{s}$ being replaced by $s!\binom{n}{s}$, and

$$ax_1^n+\frac{1}{1!}bx_1^{n-1}x_2+\frac{1}{2!}cx_1^{n-2}x_2^2+\ldots,$$

the special convenience of which will appear later. For present purposes the form will be written

$$\overline{a}_0x_1^n+\binom{n}{1}\overline{a}_1x_1^{n-1}x_2+\binom{n}{2}\overline{a}_2x_1^{n-2}x_2^2+\ldots+\overline{a}_nx_2^n,$$

the notation adopted by German writers; the literal coefficients have a rule placed over them to distinguish them from umbral coefficients which are introduced almost at once. The coefficients $\overline{a}_0$, $\overline{a}_1$, $\overline{a}_2$, ...$\overline{a}_n$, $n+1$ in number are arbitrary. If the form, sometimes termed a quantic, be equated to zero the $n+1$ coefficients are equivalent to but n, since one can be made unity by division and the equation is to be regarded as one for the determination of the ratio of the variables.

If the variables of the quantic $f(x_1, x_2)$ be subjected to the linear transformation

$$x_1=a_{11}\xi_1+a_{12}\xi_2,$$
$$x_2=a_{21}\xi_1+a_{22}\xi_2,$$

ξ_1, ξ_2 being new variables replacing x_1, x_2 and the coefficients a_{11}, a_{12}, a_{21}, a_{22}, termed the coefficients of substitution (or of transformation), being constants, we arrive at a transformed quantic

$$f(\xi_1,\xi_2)=\overline{a}_0'\xi_1^n+\binom{n}{1}\overline{a}_1'\xi_1^{n-1}\xi_2+\binom{n}{2}\overline{a}_2'\xi_1^{n-2}\xi_2+\ldots+\overline{a}_n'\xi_2^n$$

in the new variables which is of the same order as the original quantic; the new coefficients $\overline{a}_0'$, $\overline{a}_1'$, $\overline{a}_2'$...$\overline{a}_n'$ are linear functions of the original coefficients, and also linear functions of products, of the coefficients of substitution, of the *nth* degree.

By solving the equations of transformation we obtain

$$r\xi_1=\quad a_{22}x_1-a_{12}x_2,$$
$$r\xi_2=-a_{21}x_1+a_{11}x_2,$$
$$\text{where } r=\begin{vmatrix}a_{11} & a_{12}\\ a_{21} & a_{22}\end{vmatrix}=a_{11}a_{22}-a_{12}a_{21};$$

r is termed the determinant of substitution or modulus of transformation; we assume x_1, x_2 to be independents, so that r must differ from zero.

In the theory of forms we seek functions of the coefficients and variables of the original quantic which, save as to a power of the modulus of transformation, are equal to the like functions of the coefficients and variables of the transformed quantic. We may have such a function which does not involve the variables, viz.:—

$$F(\overline{a}_0', \overline{a}_1', \overline{a}_2'\ldots\overline{a}_n')=r^{\lambda}F(\overline{a}_0, \overline{a}_1, \overline{a}_2\ldots\overline{a}_n),$$

the function $F(\overline{a}_0, \overline{a}_1, \overline{a}_2\ldots\overline{a}_n)$ is then said to be an *invariant* of the quantic *quâ* linear transformation. If, however, F involve as well the variables, viz.:—

$$F(\overline{a}_0', \overline{a}_1', \overline{a}_2'\ldots;\xi_1,\xi_2)=r^{\lambda}F(\overline{a}_0, \overline{a}_1, \overline{a}_2\ldots;x_1,x_2),$$

the function $F(\overline{a}_0, \overline{a}_1, \overline{a}_2\ldots;x_1,x_2)$ is said to be a *covariant* of the quantic. The expression "invariantive forms" includes both invariants and covariants, and frequently also other analogous forms which will be met with. Occasionally the word "invariants" includes covariants; when this is so it will be implied by the text. Invariantive forms will be found to be homogeneous functions alike of the coefficients and of the variables. Instead of a single quantic we may have several

$$f(\overline{a}_0, \overline{a}_1, \overline{a}_2\ldots;x_1,x_2),\ \phi(\overline{b}_0, \overline{b}_1, \overline{b}_2\ldots;x_1,x_2),\ldots$$

which have different coefficients, the same variables, and are of the same or different degrees in the variables; we may transform them all by the same substitution, so that they become

$$f(\overline{a}_0', \overline{a}_1', \overline{a}_2'\ldots;\xi_1,\xi_2),\ \phi(\overline{b}_0', \overline{b}_1', \overline{b}_2'\ldots;\xi_1,\xi_2),\ldots$$

If then we find

$$F(\overline{a}_0', \overline{a}_1', \overline{a}_2',\ldots\overline{b}_0', \overline{b}_1', \overline{b}_2',\ldots,\ldots;\xi_1,\xi_2),$$

$$=r^{\lambda}F(\overline{a}_0, \overline{a}_1, \overline{a}_2,\ldots\overline{b}_0, \overline{b}_1, \overline{b}_2,\ldots,\ldots;x_1,x_2),$$

the function F, on the right which multiplies r^{λ}, is said to be a *simultaneous invariant* or covariant of the system of quantics. This notion is fundamental in the present theory because we will find that one of the most valuable artifices for finding invariants of a single quantic is first to find simultaneous invariants of several different quantics, and subsequently to make all the quantics identical. Moreover, instead of having one pair of variables x_1, x_2 we may have several pairs y_1, y_2; z_1, z_2;... in addition, and transform each pair to a new pair by substitutions, having the same coefficients a_{11}, a_{12}, a_{21}, a_{22} and arrive at functions of the original coefficients and variables (of one or more quantics) which possess the above-defined invariant property. A particular quantic of the system may be of the same or different degrees in the pairs of variables which it involves, and these degrees may vary from quantic to quantic of the system. Such quantics have been termed by Cayley *multipartite*.

Symbolic Form.—Restricting consideration, for the present, to binary forms in a single pair of variables, we must introduce the symbolic form of Aronhold, Clebsch, and Gordan; they write the form

$$(a_1x_1+a_2x_2)^n=a_1^nx_1^n+\binom{n}{1}a_1^{n-1}a_2x_1^{n-1}x_2+\ldots+a_2^nx_2^n=a_x^n$$

wherein a_1, a_2 are umbræ, such that

$$a_1^n,\ a_1^{n-1}a_2, \ldots a_1a_2^{n-1},\ a_2^n$$

are symbolical representations of the real coefficients $\bar{a}_0$, $\bar{a}_1$, ... $\bar{a}_{n-1}$, $\bar{a}_n$, and in general $a_1^{n-k}a_2^k$ is the symbol for $\bar{a}_k$. If we restrict ourselves to this set of symbols we can uniquely pass from a product of real coefficients to the symbolic representations of such product, but we cannot, uniquely, from the symbols recover the real form. This is clear because we can write

$$\bar{a}_1\bar{a}_2=a_1^{n-1}a_2 \,.\, a_1^{n-2}a_2^2=a_1^{2n-3}a_2^3$$

while the same product of umbræ arises from

$$\bar{a}_0\bar{a}_3=a_1^n \,.\, a_1^{n-3}a_2^3=a_1^{2n-3}a_2^3.$$

Hence it becomes necessary to have more than one set of umbræ, so that we may have more than one symbolical representation of the same real coefficients. We consider the quantic to have any number of equivalent representations $a_x^n\equiv b_x^n\equiv c_x^n\equiv\ldots$ So that $a_1^{n-k}a_2^k\equiv b_1^{n-k}b_2\equiv c_1^{n-k}c_2\equiv\ldots=\bar{a}_k$; and if we wish to denote, by umbræ, a product of coefficients of degree s we employ s sets of umbræ.

Ex. gr. We write $\quad \bar{a}_1\bar{a}_2=a_1^{n-1}a_2 \,.\, b_1^{n-2}b_2^2,$

$$\bar{a}_2^3=a_1^{n-3}a_2^3 \,.\, b_1^{n-3}b_2^3 \,.\, c_1^{n-3}c_2^3,$$

and so on whenever we require to represent a product of real coefficients symbolically; we then have a one-to-one correspondence between the products of real coefficients and their symbolic forms. If we have a function of degree s in the coefficients, we may select any s sets of umbræ for use, and having made a selection we may when only one quantic is under consideration at any time permute the sets of umbræ in any manner without altering the real significance of the symbolism. *Ex. gr.* To express the function $\bar{a}_0\bar{a}_2-\bar{a}_1^2$, which is the discriminant of the binary quadratic $\bar{a}_0x_1^2+2\bar{a}_1x_1x_2+\bar{a}_2x_2^2=a_x^2=b_x^2$, in a symbolic form we have

$$2(\bar{a}_0\bar{a}_2-\bar{a}_1^2)=\bar{a}_0\bar{a}_2+\bar{a}_0\bar{a}_2-2\bar{a}_1 \,.\, \bar{a}_1=a_1^2b_2^2+a_2^2b_1^2-2a_1a_2b_1b_2$$
$$=(a_1b_2-a_2b_1)^2.$$

Such an expression as $a_1b_2-a_2b_1$, which is

$$\frac{\partial a_x}{\partial x_1}\frac{\partial b_x}{\partial x_2}-\frac{\partial a_x}{\partial x_2}\frac{\partial b_x}{\partial x_1},$$

is usually written (ab) for brevity; in the same notation the determinant, whose rows are a_1, a_2, a_3; b_1, b_2, b_3; c_1, c_2, c_3 respectively, is written (abc) and so on. It should be noticed that the real function denoted by $(ab)^2$ is not the square of a real function denoted by (ab). For a single quantic of the first order (ab) is the symbol of a function of the coefficients which vanishes identically; thus

$$(ab)=a_1b_2-a_2b_1=\bar{a}_0\bar{a}_1-\bar{a}_1\bar{a}_0=0$$

and, indeed, from a remark made above we see that (ab) remains unchanged by interchange of a and b; but $(ab)=-(ba)$, and these two facts necessitate $(ab)=0$.

To find the effect of linear transformation on the symbolic form of quantic we will disuse the coefficients a_{11}, a_{12}, a_{21}, a_{22}, and employ λ_1, μ_1, λ_2, μ_2. For the substitution

$$x_1=\lambda_1\xi_1+\mu_1\xi_2,\ x_2=\lambda_2\xi_1+\mu_2\xi_2,$$

$$\text{of modulus } \begin{vmatrix} \lambda_1 & \mu_1 \\ \lambda_2 & \mu_2 \end{vmatrix} = (\lambda_1\mu_2-\lambda_2\mu_1)=(\lambda\mu),$$

the quadratic form $\bar{a}_0x_1^2+2\bar{a}_1x_1x_2+\bar{a}_2x_2^2=a_x^2=f(x)$, becomes

$$\bar{A}_0\xi_1^2+2\bar{A}_1\xi_1\xi_2+\bar{A}_2\xi_2^2=A_\xi^2=\phi(\xi),$$

where

$$\bar{A}_0=\bar{a}_0\lambda_1^2+2\bar{a}_1\lambda_1\lambda_2+\bar{a}_2\lambda_2^2,$$
$$\bar{A}_1=\bar{a}_0\lambda_1\mu_1+\bar{a}_1(\lambda_1\mu_2+\lambda_2\mu_1)+\bar{a}_2\lambda_2\mu_2,$$
$$\bar{A}_2=\bar{a}_0\mu_1^2+2\bar{a}_1\mu_1\mu_2+\bar{a}_2\mu_2^2.$$

We pass to the symbolic forms

$$a_x^2=(a_1x_1+a_2x_2)^2,\ A_\xi^2=(A_1\xi_1+A_2\xi_2)^2,$$

by writing for

$$\begin{array}{lll} \bar{a}_0,\ \bar{a}_1,\ \bar{a}_2 & \text{the symbols} & a_1^2,\ a_1a_2,\ a_2^2 \\ \bar{A}_0,\ \bar{A}_1,\ \bar{A}_2 & \text{,,} & A_1^2,\ A_1A_2,\ A_2^2 \end{array}$$

and then

$$\bar{A}_0=a_1^2\lambda_1^2+2a_1a_2\lambda_1\lambda_2+a_2^2\lambda_2^2=(a_1\lambda_1+a_2\lambda_2)^2=a_\lambda^2,$$
$$\bar{A}_1=(a_1\lambda_1+a_2\lambda_2)(a_1\mu_1+a_2\mu_2)=a_\lambda a_\mu,$$
$$\bar{A}_2=(a_1\mu_1+a_2\mu_2)^2=a_\mu^2;$$

so that

$$A_\xi^2=a_\lambda^2\xi_1^2+2a_\lambda a_\mu\xi_1\xi_2+a_\mu^2\xi_2^2=(a_\lambda\xi_1+a_\mu\xi_2)^2;$$

whence A_1, A_2 become a_λ, a_μ respectively and

$$\phi(\xi)=(a_\lambda\xi_1+a_\mu\xi_2)^2.$$

The practical result of the transformation is to change the umbræ a_1, a_2 into the umbræ

$$a_\lambda=a_1\lambda_1+a_2\lambda_2,\ a_\mu=a_1\mu_1+a_2\mu_2$$

respectively.

By similarly transforming the binary n^{ic} form a_x^n we find

$$\bar{A}_0=(a_1\lambda_1+a_2\lambda_2)^n=a_\lambda^n=A_1^n,$$
$$\bar{A}_1=(a_1\lambda_1+a_2\lambda_2)^{n-1}(a_1\mu_1+a_2\mu_2)=a_\lambda^{n-1}a_\mu=A_1^{n-1}A_2,$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$
$$\bar{A}_k=(a_1\lambda_1+a_2\lambda_2)^{n-k}(a_1\mu_1+a_2\mu_2)^k=a_\lambda^{n-k}a_\mu^k=A_1^{n-k}A_2^k,$$

so that the umbræ A_1, A_2 are a_λ, a_μ respectively.

Theorem.—When the binary form

$$a_x^n=(a_1x_1+a_2x_2)^n,$$

is transformed to

$$A_\xi^n=(A_1\xi_1+A_2\xi_2)^n,$$

by the substitutions

$$x_1=\lambda_1\xi_1+\mu_1\xi_2,\ x_2=\lambda_2\xi_1+\mu_2\xi_2,$$

the umbræ A_1, A_2 are expressed in terms of the umbræ a_1, a_2 by the formulas

$$A_1=\lambda_1a_1+\lambda_2a_2,\ A_2=\mu_1a_1+\mu_2a_2.$$

We gather that A_1, A_2 are transformed to a_1, a_2 in such wise that the determinant of transformation reads by rows as the original determinant reads by columns, and that the modulus of the transformation is, as before, $(\lambda\mu)$. For this reason the umbræ A_1, A_2 are said to be *contragredient* to x_1, x_2. If we solve the equations connecting the original and transformed umbræ we find

$$(\lambda\mu)(-a_2)=\lambda_1(-A_2)+\mu_1A_1,$$
$$(\lambda\mu)a_1\qquad=\lambda_2(-A_2)+\mu_2A_1,$$

and we find that, except for the factor $(\lambda\mu)$, $-a_2$ and $+a_1$ are transformed to $-A_2$ and $+A_1$ by the same substitutions as x_1 and x_2 are transformed to ξ_1 and ξ_2. For this reason the umbræ $-a_2$, a_1 are said to be cogredient to x_1 and x_2. We frequently meet with cogredient and contragredient quantities, and we have in general the following definitions:—(1) "If two equally numerous sets of quantities x, y, z, ... x', y', z', ... are such that whenever one set x, y, z, ... is expressed in terms of new quantities X, Y, Z, ... the second set x', y', z', ... is expressed in terms of other new quantities X′, Y′, Z′, ..., by the same scheme of linear substitution the two sets are said to be *cogredient* quantities." (2) "Two sets of quantities x, y, z, ...; ξ, η, ζ, ... are said to be *contragredient* when the linear substitutions for the first set are

$$x=\lambda_1X+\mu_1Y+\nu_1Z+\ldots,$$
$$y=\lambda_2X+\mu_2Y+\nu_2Z+\ldots,$$
$$z=\lambda_3X+\mu_3Y+\nu_3Z+\ldots,$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot$$

and these are associated with the following formulæ appertaining to the second set,

$$\Xi=\lambda_1\xi+\lambda_2\eta+\lambda_3\zeta+\ldots,$$
$$\mathrm{H}=\mu_1\xi+\mu_2\eta+\mu_3\zeta+\ldots,$$
$$\mathrm{Z}=\nu_1\xi+\nu_2\eta+\nu_3\zeta+\ldots,$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot$$

wherein it should be noticed that *new* quantities are expressed in terms of the *old*, as regards the latter set, and not *vice versâ*."

Ex. gr. The symbols $\dfrac{d}{dx}$, $\dfrac{d}{dy}$, $\dfrac{d}{dz}$, ... are contragredient with the variables x, y, z, ... for when

$$(x,\ y,\ z,\ \ldots)=\begin{vmatrix} \lambda_1, & \mu_1, & \nu_1, & \ldots \\ \lambda_2, & \mu_2, & \nu_2, & \ldots \\ \lambda_3, & \mu_3, & \nu_3, & \ldots \\ \cdot & \cdot & \cdot & \cdot \end{vmatrix}(X,\ Y,\ Z,\ \ldots),$$

we find

$$\left(\frac{d}{dX}, \frac{d}{dY}, \frac{d}{dZ}, \ldots\right) = \left(\begin{array}{cccc}\lambda_1, & \lambda_1, & \lambda_3, & \ldots \\ \mu_1, & \mu_2, & \mu_3, & \ldots \\ \nu_1, & \nu_2, & \nu_3, & \ldots \\ . & . & . & .\end{array}\right)\left(\frac{d}{dx}, \frac{d}{dy}, \frac{d}{dz}, \ldots\right).$$

Observe the notation, which is that introduced by Cayley into the theory of matrices which he himself created.

Just as cogrediency leads to a theory of covariants, so contragrediency leads to a theory of contravariants. If u, a quantic in $x, y, z, \ldots$, be expressed in terms of new variables X, Y, Z ...; and if $\xi, \eta, \zeta, \ldots$ be quantities contragredient to $x, y, z, \ldots$; there are found to exist functions of $\xi, \eta, \zeta, \ldots$, and of the coefficients in u, which need, at most, be multiplied by powers of the modulus to be made equal to the same functions of Ξ, H, Z, ... of the transformed coefficients of u; such functions are called *contravariants* of u. There also exist functions, which involve both sets of variables as well as the coefficients of u, possessing a like property; such have been termed *mixed concomitants*, and they, like contravariants, may appertain as well to a system of forms as to a single form.

As between the original and transformed quantic we have the umbral relations

$$A_1 = \lambda_1 a_1 + \lambda_2 a_2,\ A_2 = \mu_1 a_1 + \mu_2 a_2,$$

and for a second form

$$B_1 = \lambda_1 b_1 + \lambda_2 b_2,\ B_2 = \mu_1 b_1 + \mu_2 b_2.$$

The original forms are a_x^n, b_x^n, and we may regard them *either* as *different* forms *or* as equivalent representations of the *same* form. In other words, B, b may be regarded as different or alternative symbols to A, a. In either case

$$(AB) = A_1B_2 - A_2B_1 = (\lambda\mu)(ab);$$

and, from the definition, (ab) possesses the invariant property. We cannot, however, say that it is an invariant unless it is expressible in terms of the real coefficients. Since $(ab) = a_1b_2 - a_2b_1$, that this may be the case each form must be linear; and if the forms be different (ab) is an invariant (simultaneous) of the two forms, its real expression being $\bar{a}_0\bar{b}_1 - \bar{a}_1\bar{b}_0$. This will be recognized as the resultant of the two linear forms. If the two linear forms be identical, the umbral sets a_1, a_2; b_1, b_2 are alternative, are ultimately put equal to one another and (ab) vanishes. A single linear form has, in fact, no invariant. When either of the forms is of an order higher than the first (ab), as not being expressible in terms of the actual coefficients of the forms, is not an invariant and has no significance. Introducing now other sets of symbols C, D, ...; $c, d, \ldots$ we may write

$$(AB)^i(AC)^j(BC)^k\ldots = (\lambda\mu)^{i+j+k+\cdots}(ab)^i(ac)^j(bc)^k\ldots,$$

so that the symbolic product

$$(ab)^i(ac)^j(bc)^k\ldots,$$

possesses the invariant property. If the forms be all linear and different the function is an invariant, viz., the i^{th} power of that appertaining to a_x and b_x multiplied by the j^{th} power of that appertaining to a_x and c_x multiplied by &c. If any two of the linear forms, say p_x, q_x, be supposed identical, any symbolic expression involving the factor (pq) is zero. Notice, therefore, that the symbolic product $(ab)^i(ac)^j(bc)^k\ldots$ may be always viewed as a simultaneous invariant of a number of different linear forms $a_x, b_x, c_x, \ldots$. In order that $(ab)^i(ac)^j(bc)^k\ldots$ may be a simultaneous invariant of a number of different forms $a_x^{n_1}, b_x^{n_2}, c_x^{n_3}, \ldots$, where $n_1, n_2, n_3, \ldots$ may be the same or different, it is necessary that every product of umbræ which arises in the expansion of the symbolic product be of degree n_1 in a_1, a_2; in the case of b_1, b_2 of degree n_2; in the case of c_1, c_2 of degree n_3; and so on. For these only will the symbolic product be replaceable by a linear function of products of real coefficients. Hence the condition is

$$\begin{aligned} i + j + \ldots &= n_1, \\ i + k + \ldots &= n_2, \\ j + k + \ldots &= n_3, \\ . \quad . \quad &. \quad . \end{aligned}$$

If the forms $a_x^n, b_x^n, c_x^n \ldots$ be identical the symbols are alternative, and provided that the form does not vanish it denotes an invariant of the single form a_x^n.

There may be a number of forms $a_x^n, b_x^n, c_x^n, \ldots$ and we may suppose such identities between the symbols that on the whole only two, three, or more of the sets of umbræ are not equivalent; we will then obtain invariants of two, three, or more sets of binary forms. The symbolic expression of a covariant is equally simple, because we see at once that since A_ξ, B_ξ, C_ξ, ... are equal to $a_x, b_x, c_x, \ldots$ respectively, the linear forms $a_x, b_x, c_x, \ldots$ possess the invariant property, and we may write

$$(AB)^i(AC)^j(BC)^k\ldots A_\xi^\rho B_\xi^\sigma C_\xi^\tau\ldots$$
$$= (\lambda\mu)^{i+j+k+\cdots}(ab)^i(ac)^j(bc)^k\ldots a_x^\rho b_x^\sigma c_x^\tau\ldots,$$

and assert that the symbolic product

$$(ab)^i(ac)^j(bc)^k\ldots a_x^\rho b_x^\sigma c_x^\tau\ldots$$

possesses the invariant property. It is always an invariant or covariant appertaining to a number of different linear forms, and as before it may vanish if two such linear forms be identical. In general it will be simultaneous covariant of the different forms $a_x^{n_1}, b_x^{n_2}, c_x^{n_3}, \ldots$ if

$$\begin{aligned} i + j + \ldots + \rho &= n_1, \\ i + k + \ldots + \sigma &= n_2, \\ j + k + \ldots + \tau &= n_3, \\ . \quad . \quad &. \quad . \end{aligned}$$

It will also be a covariant if the symbolic product be factorizable into portions each of which satisfies these conditions. If the forms be identical the sets of symbols are ultimately equated, and the form, provided it does not vanish, is a covariant of the form a_x^n.

The expression $(ab)^4$ properly appertains to a quartic; for a quadratic it may also be written $(ab)^2(cd)^2$, and would denote the square of the discriminant to a factor *pres.* For the quartic

$$\begin{aligned}(ab)^4 = (a_1b_2 - a_2b_1)^4 &= a_1^4b_2^4 - 4a_1^3a_2b_1b_2^3 + 6a_1^2a_2^2b_1^2b_2^2 \\ &- 4a_1a_2^3b_1^3b_2 + a_2^4b_1^4 = \bar{a}_0\bar{a}_4 - 4\bar{a}_1\bar{a}_3 + 6\bar{a}_2^2 - 4\bar{a}_1\bar{a}_3 + \bar{a}_0\bar{a}_4 \\ &= 2(\bar{a}_0\bar{a}_4 - 4\bar{a}_1\bar{a}_3 + 3\bar{a}_2^2),\end{aligned}$$

one of the well-known invariants of the quartic.

For the cubic $(ab)^2a_xb_x$ is a covariant because each symbol a, b occurs three times; we can first of all find its real expression as a simultaneous covariant of two cubics, and then, by supposing the two cubics to merge into identity, find the expression of the quadratic covariant, of the single cubic, commonly known as the Hessian.

By simple multiplication

$$\begin{aligned}&(a_1^3b_1b_2^2 - 2a_1^2a_2b_1^2b_2 + a_1a_2^2b_1^3)x_1^2 \\ &+ (a_1^3b_2^3 - a_1a_2^2b_1^2b_2 - a_1^2a_2b_1b_2^2 + a_2^3b_1^3)x_1x_2 \\ &+ (a_1^2a_2b_2^3 - 2a_1a_2^2b_1b_2^2 + a_2^3b_1^2b_2)x_2^2;\end{aligned}$$

and transforming to the real form,

$$\begin{aligned}(a_0b_2 - 2a_1b_1 + a_2b_0)x_1^2 &+ (a_0b_3 - a_1b_2 - a_2b_1 + a_3b_0)x_1x_2 \\ &+ (a_1b_3 - 2a_2b_2 + a_3b_1)x_2^2,\end{aligned}$$

the simultaneous covariant; and now, putting $b = a$, we obtain twice the Hessian

$$(a_0a_2 - a_1^2)x_1^2 + (a_0a_3 - a_1a_2)x_1x_2 + (a_1a_3 - a_2^2)x_2^2.$$

It will be shown later that all invariants, single or simultaneous, are expressible in terms of symbolic products. The degree of the covariant in the coefficients is equal to the number of different symbols $a, b, c, \ldots$ that occur in the symbolic expression; the degree in the variables (*i.e.* the order of the covariant) is $\rho + \sigma + \tau + \ldots$ and the weight* of the coefficient of the leading term $x_1^{\rho+\sigma+\tau+\ldots}$ is equal to $i + j + k + \ldots$. It will be apparent that there are four numbers associated with a covariant, viz., the orders of the quantic and covariant, and the degree and weight of the leading coefficient; calling these n, ϵ, θ, w respectively we can see that they are not independent integers, but that they are invariably connected by a certain relation $n\theta - 2w = \epsilon$. For, if $\phi(\bar{a}_0, \ldots x_1, x_2)$ be a covariant of order ϵ appertaining to a quantic of order n,

$$\phi(\bar{A}_0, \ldots \xi_1, \xi_2) = (\lambda\mu)^w\phi(\bar{a}_0, \ldots \lambda_1\xi_1 + \mu_1\xi_2, \lambda_2\xi_1 + \mu_2\xi_2);$$

we find that the left- and right-hand sides are of degrees $n\theta$ and $2w + \epsilon$ respectively in $\lambda_1, \mu_1, \lambda_2, \mu_2$, and thence $n\theta = 2w + \epsilon$.

Symbolic Identities.—For the purpose of manipulating symbolic expressions it is necessary to be in possession of certain simple identities which connect certain symbolic products. From the three equations

$$a_x = a_1x_1 + a_2x_2,\ b_x = b_1x_1 + b_2x_2,\ c_x = c_1x_1 + c_2x_2,$$

we find by eliminating x_1 and x_2 the relation

$$a_x(bc) + b_x(ca) + c_x(ab) = 0 \quad . \quad . \quad \text{(I.)}$$

Introduce now new umbræ d_1, d_2 and recall that $+d_2$, $-d_1$, are cogredient with x_1 and x_2. We may in any relation substitute for any pair of quantities any other cogredient pair so that writing $+d_2, -d_1$ for x_1 and x_2, and noting that g_x then becomes (gd), the above-written identity becomes

---

* The weight of a term $\bar{a}_0^{k_0}\bar{a}_1^{k_1}\ldots\bar{a}_n^{k_n}$ is defined as being $k_1 + 2k_2 + \ldots + nk_n$.

$$(ad)(bc)+(bd)(ca)+(cd)(ab)=0 \quad . \quad . \quad \text{(II.)}$$

Similarly in (I.), writing for c_1, c_2, the cogredient pair $-y_2, +y_1$, we obtain

$$a_x b_y - a_y b_x = (ab)(xy). \quad . \quad . \quad . \quad \text{(III.)}$$

Again in (I.) transposing $a_x(bc)$ to the other side and squaring, we obtain

$$2(ac)(bc)a_x b_x = (bc)^2 a_x^2 + (ac)^2 b_x - (ab)^2 c_x^2 \quad . \quad \text{(IV.)}$$

and herein writing $d_2, -d_1$ for x_1, x_2,

$$2(ac)(bc)(ad)(bd) = (bc)^2(ad)^2 + (ac)^2(bd)^2 - (ab)^2(cd)^2. \quad \text{(V.)}$$

As an illustration multiply (IV.) throughout by $a_x^{n-2}b_x^{n-2}c_x^{n-2}$ so that each term may denote a covariant of an n^{ic}.

$$2(ac)(bc)a_x^{n-1}b_x^{n-1}c_x^{n-1}$$
$$=(bc)^2 a_x^n b_x^{n-2} c_x^{n-2} + (ac)^2 a_x^{n-2} b_x^n c_x^{n-2} - (ab)^2 a_x^{n-2} b_x^{n-2} c_x^n.$$

Each term on the right-hand side may be shown by permutation of a, b, c to be the symbolical representation of the same covariant; they are equivalent symbolic products, and we may accordingly write

$$2(ac)(bc)a_x^{n-1}b_x^{n-1}c_x^{n-2} = (ab)^2 a_x^{n-2} b_x^{n-2} c_x^n,$$

a relation which shows that the form on the left is the product of the two covariants

$$(ab)^2 a_x^{n-2} b_x^{n-2} \text{ and } c_x^n.$$

The identities are, in particular, of service in reducing symbolic products to standard forms. A symbolical expression may be always so transformed that the power of any determinant factor (ab) is even. For we may in any product interchange a and b without altering its signification; therefore

$$(ab)^{2m+1}\phi_1 = -(ab)^{2m+1}\phi_2,$$

where ϕ_1 becomes ϕ_2 by the interchange, and hence

$$(ab)^{2m+1}\phi_1 = \frac{1}{2}(ab)^{2m+1}(\phi_1 - \phi_2);$$

and identity (I.) will always result in transforming $\phi_1 - \phi_2$ so as to make it divisible by (ab).

Ex. gr.

$$(ab)(ac)b_x c_x = -(ab)(bc)a_x c_x$$
$$= \frac{1}{2}(ab)c_x\{(ac)b_x - (bc)a_x\} = \frac{1}{2}(ab)^2 c_x^2;$$

so that the covariant of the quadratic on the left is half the product of the quadratic itself and its only invariant. To obtain the corresponding theorem concerning the general form of even order we multiply throughout by $(ab)^{2m-2}c_x^{2m-2}$ and obtain

$$(ab)^{2m-1}(ac)b_x c_x^{2m-1} = \frac{1}{2}(ab)^{2m}c_x^{2m}.$$

Paying attention merely to the determinant factors there is no form with one factor since (ab) vanishes identically. For two factors the standard form is $(ab)^2$; for three factors $(ab)^2(ac)$; for four factors $(ab)^4$ and $(ab)^2(cd)^2$; for five factors $(ab)^4(ac)$ and $(ab)^2(ac)(de)^2$; for six factors $(ab)^6$, $(ab)^2(bc)^2(ca)^2$, and $(ab)^2(cd)^2(ef)^2$. It will be a useful exercise for the reader to interpret the corresponding covariants of the general quantic, to show that some of them are simple powers or products of other covariants of lower degrees and order.

The Polar Process.—We are now going to introduce other sets of cogredient variables into the symbolic products. The μ^{th} polar of the binary form $a_x^n = f$ with regard to y is expressed by

$$(a_x^n)_y^\mu = f_y^\mu = (a_1x_1 + a_2x_2)^{n-\mu}(a_1y_1 + a_2y_2)^\mu = a_x^{n-\mu}a_y^\mu;$$

i.e., μ of the symbolic factors of the form are replaced by μ others in which y_1, y_2, replace x_1, x_2.

By giving μ the values 0, 1, 2, ... n we obtain in all $n+1$ y-polars in regard to x. They may be obtained by partial differential operations upon the form. Write in symbolic form

$$\frac{\partial^\mu f}{\partial x_1^a \partial x_2^{\mu-a}} = \frac{n!}{(n-\mu)!}f_1^a f_2^{\mu-a},$$

so that

$$\frac{\partial f}{\partial x_1} = nf_1, \quad \frac{\partial f}{\partial x_2} = nf_2;$$

and let

$$f_y = f_1y_1 + f_2y_2;$$

then

$$nf_1 = na_x^{n-1}a_1, \quad nf_2 = na_x^{n-1}a_2;$$
$$f_y = a_x^{n-1}a_y,$$

the first polar.

Similarly

$$f_1^2 = a_x^{n-2}a_1^2, \; f_1f_2 = a_x^{n-2}a_1a_2, \; f_2^2 = a_x^{n-2}a_2^2,$$
$$f_y^2 = (f_1y_1 + f_2y_2)^2 = a_x^{n-2}a_y^2,$$

the second polar; and in general the μ^{th} polar is

$$f_y^\mu = (f_1y_1 + f_2y_2)^\mu = a_x^{n-\mu}a_y^\mu$$
$$= \sum \binom{\mu}{a} y_1^a y_2^{\mu-a} f_1^a f_2^{\mu-a}$$
$$= \frac{(n-\mu)!}{n!} \sum \binom{\mu}{a} y_1^a y_2^{\mu-a} \frac{\partial^\mu f}{\partial x_1^a \partial x_2^{\mu-a}}.$$

In symbolic form we may write

$$f_y^\mu = \frac{(n-\mu)!}{n!}\left(y_1\frac{\partial}{\partial x_1} + y_2\frac{\partial}{\partial x_2}\right)^\mu f = \frac{(n-\mu)!}{n!} y_\delta^\mu f.$$

All the polars may be generated from a_x^n by writing therein $x_1 + \lambda y_1, x_2 + \lambda y_2$ for x_1, x_2 respectively, for a_x^n becomes $(a_x + \lambda a_y)^n$ and

$$(a_x + \lambda a_y)^n = a_x^n + \binom{n}{1}\lambda a_x^{n-1}a_y + \binom{n}{2}\lambda^2 a_x^{n-2}a_y^2 + \ldots + \lambda^n a_y^n$$
$$= f_y^0 + \binom{n}{1}\lambda f_y^1 + \binom{n}{2}\lambda^2 f_y^2 + \ldots + \lambda^n f_y^n.$$

Ex. gr. The first polar of $a_x^2 = a_x a_y$

$$= (a_1x_1 + a_2x_2)(a_1y_1 + a_2y_2) = a_1^2x_1y_1 + a_1a_2(x_1y_2 + x_2y_1) + a_2^2x_2y_2$$
$$= \bar{a}_0x_1y_1 + \bar{a}_1(x_1y_2 + x_2y_1) + \bar{a}_2x_2y_2$$
$$= (\bar{a}_0x_1 + \bar{a}_1x_2)y_1 + (\bar{a}_1x_1 + \bar{a}_2x_2)y_2$$
$$= \frac{1}{2}\left(y_1\frac{d}{dx_1} + y_2\frac{d}{dx_2}\right)(\bar{a}_0x_1^2 + 2\bar{a}_1x_1x_2 + \bar{a}_2x_2^2).$$

Similarly the second polar of the binary cubic is

$$(\bar{a}_0x_1 + \bar{a}_1x_2)y_1^2 + 2(\bar{a}_1x_1 + \bar{a}_2x_2)y_1y_2 + (\bar{a}_2x_1 + \bar{a}_3x_2)y_2^2$$

which is $a_x a_y^2$ or

$$\frac{1}{6}\left(y_1\frac{d}{dx_1} + y_2\frac{d}{dx_2}\right)^2 a_x^3.$$

The operation of taking the polar results in a symbolic product and the repetition of the process, in regard to new cogredient sets of variables, must result in symbolic forms. It is therefore an invariant process, and all the forms obtained are invariants in regard to linear transformations, in accordance with the same scheme of substitutions, of the several sets of variables.

An important associated operation is

$$\frac{\partial^2}{\partial x_1 \partial y_2} - \frac{\partial^2}{\partial x_2 \partial y_1},$$

which performed upon any polar causes it to vanish; for

$$\frac{\partial^2}{\partial x_1 \partial y_2}a_x^{n-\mu}a_y^\mu = (n-\mu)\mu a_1a_2a_x^{n-\mu-1}a_y^{\mu-1};$$

and conversely it can be shown that every function which it causes to vanish is a polar.

It is usual to write

$$\frac{1}{m.n}\left(\frac{\partial^2}{\partial x_1 \partial y_2} - \frac{\partial^2}{\partial x_2 \partial y_1}\right)a_x^m b_y^n = \Omega a_x^m b_y^n,$$

and we have the theorem that Ω, performed upon any invariant form, produces an invariant form.

Ex. gr.

$$\Omega a_x^m b_x^n = \frac{1}{m.n}(mna_1b_2 - mna_2b_1)a_x^{m-1}b_x^{n-1},$$
$$= (ab)a_x^{m-1}b_x^{n-1};$$
$$\Omega^2 a_x^m b_x^n = (ab)^2 a_x^{m-2} b_y^{n-2};$$

and in general

$$\Omega^\mu a_x^m b_y^n = (ab)^\mu a_x^{m-\mu} b_y^{n-\mu}.$$

These are invariants of forms which are binary in two sets of variables and, by putting $y=x$, we obtain simultaneous invariants of two binary forms in a single set of variables. Observe the easy passage from a bipartite form to two unipartite forms. The polar of a product $a_x^m . b_x^n$ is obtained by, first of all, writing $a_x^m . b_x^n$ in the symbolic form p_x^{m+n}; thus if

$$F = a_x^m . b_x^n = p_x^{m+n},$$
$$F_y^k = p_x^{m+n-k}p_y^k;$$

now, in $p_x^{m+n} = a_x^m . b_x^n$, write $x + \lambda y$ for x, so that

$$(p_x + \lambda p_y)^{m+n} = (a_x + \lambda a_y)^m . (b_x + \lambda b_y)^n;$$

expanding and comparing coefficients of λ^k

$$\binom{m+n}{k}p_x^{m+n-k}p_y^k=\sum_s\binom{m}{s}\binom{n}{k-s}a_x^{m-s}a_y^s b_x^{n-k+s}b_y^{k-s};$$

or writing $a_x^m=f,\ b_x^n=\phi$,

$$\binom{m+n}{k}(f.\phi)_y^k=\sum_s\binom{m}{s}\binom{n}{k-s}f_y^s\phi_y^{k-s},$$

a general formula for the polar of a product of two forms. The expression $f_y^s\phi_y^{k-s}$ is called a *member* of the polar; writing it G_s we have altogether a series of $k+1$ members, viz.—

$$G_0,\ G_1,\ G_2,\ \ldots G_k;$$

and

$$\binom{m+n}{k}(f.\phi)_y^k=\sum_s\binom{m}{s}\binom{n}{k-s}G_s.$$

Two members, G_s, G_{s+1}, are said to be adjacent, and we can prove that the difference between any two adjacent members contains the factor $(ab)(xy)$; for

$$\begin{aligned}G_s-G_{s+1}&=f_y^s\phi_y^{k-s}-f_y^{s+1}\phi_y^{k-s-1}\\&=a_x^{m-s-1}a_y^s b_x^{n-k+s}b_y^{k-s-1}\,(ab)(xy);\end{aligned}$$

whence also

$$a_x b_x(G_s-G_{s+1})=f_y^s\phi_y^{k-s-1}\,(ab)(xy),$$

wherein $f_y^s\phi_y^{k-s-1}$ is a member of the $k-1$th polar of $F=f.\phi$. Again, if s be less than t,

$$G_s-G_t=G_s-G_{s+1}+G_{s+1}-G_{s+2}+\ldots+G_{t-1}-G_t;$$

and since the successive differences

$$G_s-G_{s+1},\ G_{s+1}-G_{s+2},\ldots G_{t-1}-G_t,$$

involve, each of them, the factor $(ab)(xy)$; so also does G_s-G_t the difference between any two members of the polar. Also the cofactor of $(ab)(xy)$ in $a_x b_x(G_s-G_t)$ must be a sum of members of the $k-1$th polar of F.

Moreover, since

$$\binom{m+n}{k}F_y^k=\sum_s\binom{m}{s}\binom{n}{k-s}G_s,$$

and

$$\sum_s\binom{m}{s}\binom{n}{k-s}=\binom{m+n}{k},$$

we may write

$$F_y^k=c_0G_0+c_1G_1+\ldots+c_kG_k,$$

where $c_0+c_1+\ldots+c_k=1$, and

$$G_s=(c_0+c_1+\ldots+c_k)G_s;$$

we obtain, by subtraction,

$$F_y^k-G_s=c_0(G_0-G_s)+c_1(G_1-G_s)+\ldots+c_k(G_k-G_s),$$

which proves that the difference between the complete polar and any one of its members contains the factor $(ab)(xy)$, and that the cofactor of $a_xb_x(F_y^k-G_s)$ is a linear function of the members of the $k-1$th polar of F. Since

$$a_xb_x(G_s-G_t)=\left(f_y^s\phi_y^{k-s-1}+f_y^{s+1}\phi_y^{k-s-2}+\ldots+f_y^{t-1}\phi_y^{k-t}\right)(ab)(xy),$$

we find

$$\begin{aligned}&a_xb_x(F_y^k-G_s)\div(ab)(xy)\\&=c_0f_y^0\phi_y^{k-1}+(c_0+c_1)f_y^1\phi_y^{k-2}+\ldots+(c_0+c_1+\ldots+c_{s-1})f_y^{s-1}\phi_y^{k-s}\\&-(c_s+c_{s+1}+\ldots+c_k)f_y^s\phi_y^{k-s-1}-\ldots-c_kf_y^{k-1}\phi_y^0;\end{aligned}$$

and we see that the cofactor of (xy) in $F_y^k-G_s$ is a sum of terms obtained by writing (ab) for a_xb_x, in the cofactor of $(ab)(xy)$, in the expression of $a_xb_x(F_y^k-G_s)$. Hence the cofactor of (xy) in $F_y^k-G_s$ is a linear function of the members of the $k-1$th polar of $(ab)a_x^{m-1}b_x^{n-1}$, which is a covariant of $F=f.\phi$, usually written $(f,\phi)^1$ and termed (*see post*) the first transvectant of f over ϕ. The $k-1$th polar will be written

$$\left\{(f,\phi)^1\right\}_y^{k-1},$$

and

$$G\left\{(f,\phi)^1\right\}_y^{k-1}$$

will denote one of its members. We thus have the relation

$$G_s=G_s\left\{(f,\phi)\right\}_y^k=\left\{(f,\phi)\right\}_y^k+(xy)\sum cG\left\{(f,\phi)^1\right\}_y^{k-1};$$

or, in words, we express a member of the kth polar of $f.\phi$ as a sum of the polar itself, and the product of (xy) into a linear function of the members of the $k-1$th polar of the first transvectant of f over ϕ. We may similarly treat any member

$$G\left\{(f,\phi)^1\right\}_y^{k-1}$$

of the $k-1$th polar of the first transvectant, so as to exhibit it as a sum of the polar itself and a product of (xy) into a linear function of the members of the $k-2$th polar of the second transvectant,

$$(ab)^2a_x^{m-2}b_x^{n-2}=(f,\phi)^2,$$

of f over ϕ; we can continue the process so as finally to reach the development

$$\begin{aligned}G_s=\left\{(f,\phi)\right\}_y^k&+(xy)c_1\left\{(f,\phi)^1\right\}_y^{k-1}\\&+(xy)^2c_2\left\{(f,\phi)^2\right\}_y^{k-2}+\ldots+(xy)^kc_k(f,\phi)^k.\end{aligned}$$

Hence the theorem which states that any member of the kth polar of the product of two forms f,ϕ may be expanded in ascending powers of the determinant (xy), the cofactor of $(xy)^s$ being a numerical multiple of the $k-s$th polar of the sth transvectant of f over ϕ. All of these transvectants are, as we shall show presently, covariants.

Ex. gr. Let $F=f.\phi=a_x^3.b_x^3$; and let us exhibit the second member of the second polar in the desired form,

$$\binom{6}{2}F_y^2=\binom{3}{0}\binom{3}{2}F_y^0\phi_y^2+\binom{3}{1}\binom{3}{1}F_y^1\phi_y^1+\binom{3}{2}\binom{3}{0}f_y^2\phi_y^0,$$

or

$$F_y^2=\frac{1}{5}\left(a_x^3b_xb_y^2+3a_x^2a_yb_x^2b_y+a_xa_y^2b_x^3\right);$$

the second member is $a_x^2a_yb_x^2b_y$ and

$$\begin{aligned}F_y^2-a_x^2a_yb_x^2b_y&=\frac{1}{5}\left(a_x^3b_xb_y^2-a_x^2a_yb_x^2b_y+a_xa_y^2b_x^3-a_x^2a_yb_x^2b_y\right)\\&=\frac{1}{5}a_xb_x(a_xb_y-a_yb_x)^2\\&=\frac{1}{5}(xy)^2(ab)^2a_xb_x=\frac{1}{5}(xy)^2(f,\phi)^2;\end{aligned}$$

therefore

$$a_x^2a_yb_x^2b_y=F_y^2-\frac{1}{5}(xy)^2(f,\phi)^2,$$

the result. In this instance the term, involving the first power of (xy), happens to be absent. In regard to the polar of a product of n forms it is easy to establish that if

$$\begin{aligned}F_1=a_x^{m_1},\ f_2=b_x^{m_2}&\ldots f_n=n_x^{m_n},\\\binom{\Sigma m}{k}&(f_1f_2\ldots f_n)_y^k\\=\sum\binom{m_1}{i_1}\binom{m_2}{i_2}&\ldots\binom{m_n}{i_n}(f_1)_y^{i_1}(f_2)_y^{i_2}\ldots(f_n)_y^{i_n},\end{aligned}$$

where

$$\Sigma i=k.$$

As regards polars, with more than two sets of cogredient variables, the generating function is

$$(a_x+\lambda a_y+\mu a_z+\ldots)^m;$$

and we can establish the theorem that every symbolic product involving several sets of cogredient variables can be expanded into a number of terms, each of which is a complete polar, multiplied by a product of powers of the determinant factors (xy), (xz), (yz), ….

Transvection.—Certain covariants, termed transvectants, have been met with above. We have seen that (ab) is a simultaneous invariant of the two different linear forms $f=a_x$, $\phi=b_x$, and we observe that (ab) is equivalent to the differential operation

$$\frac{\partial f}{\partial x_1}\frac{\partial\phi}{\partial x_2}-\frac{\partial f}{\partial x_2}\frac{\partial\phi}{\partial x_1}.$$

The process is generalized by forming the function

$$\frac{(m-k)!}{m!}\frac{(n-k)!}{n!}\left(\frac{\partial f}{\partial x_1}\frac{\partial\phi}{\partial x_2}-\frac{\partial f}{\partial x_2}\frac{\partial\phi}{\partial x_1}\right)^k,$$

where f, ϕ are any two binary forms; it is called the kth transvectant of f over ϕ. It should be noted that the multiplication of operations is symbolic in the sense that the operation in the bracket is to be performed k times successively. The transvectant is denoted by

$$(f,\ \phi)^k.$$

Thus if

$$\begin{aligned}f=a_x^m,\ &\phi=b_x^n,\\(a_x^m,\ b_x^n)^1&=(ab)a_x^{m-1}b_x^{n-1},\\(a_x^m,\ b_x^n)^k&=(ab)^ka_x^{m-k}b_x^{n-k},\end{aligned}$$

from which it is evident that the kth transvectant is a simultaneous covariant of the two forms.

If $m \geq n$ there are $n+1$ transvectants corresponding to the values 0, 1, 2,...n of k; if $k=0$ we have the product of the two forms, and for all values of $k>n$ the transvectants vanish. In general we may have any two forms

$$\phi^p = (\phi_1 x_1 + \phi_2 x_2)^p,\ \psi_x^q = (\psi_1 x_1 + \psi_2 x_2)^q,$$

ϕ_1, ϕ_2; ψ_1, ψ_2 being the umbræ, as usual, and for the k^{th} transvectant we have

$$(\phi_x^p, \psi_x^q)^k = (\phi\psi)^k \phi_x^{p-k} \psi_x^{q-k},$$

a simultaneous covariant of the two forms. We may suppose ϕ_x^p, ψ_x^q to be any two covariants appertaining to a system, and the process of transvection supplies a means of proceeding from them to other covariants.

The two forms a_x^m, b_x^n, or ϕ_p, ψ_x^q, may be identical; we then have the k^{th} transvectant of a form over itself which may, or may not, vanish identically; and, in the latter case, is a covariant of the single form. It is obvious that, when k is uneven, the k^{th} transvectant of a form over itself *does* vanish. We have seen that transvection is equivalent to the performance of partial differential operations upon the two forms, but, practically, we may regard the process as merely substituting $(ab)^k$, $(\phi\psi)^k$ for $a_x^k b_x^k$, $\phi_x^k \psi_x^k$ respectively in the symbolic product subjected to transvection. It is essentially an operation performed upon the product of two forms. If, then, we require the transvectants of the two forms $f+\lambda f'$, $\phi+\mu\phi'$, we take their product

$$f\phi + \lambda f'\phi + \mu f\phi' + \lambda\mu f'\phi',$$

and the k^{th} transvectant is simply obtained by operating upon each term separately, viz.:—

$$(f, \phi)^k + \lambda(f', \phi)^k + \mu(f, \phi')^k + \lambda\mu(f', \phi')^k;$$

and, moreover, if we require to find the k^{th} transvectant of one linear system of forms over another we have merely to multiply the two systems, and take the k^{th} transvectant of the separate products.

The process of transvection is connected with the operations Ω; for

$$\Omega^k (a_x^m b_y^n) = (ab)^k a_x^{m-k} b_y^{n-k};$$

or

$$\Omega^k (a_x^m b_y^n)_{y=x} = (f, \phi)^k;$$

so also is the polar process, for since

$$f_y^k = a_x^{m-k} b_y^k,\ \phi_y^k = b_x^{n-k} b_y^k,$$

if we take the k^{th} transvectant of f_y^k over ϕ_y^k, regarding y_1, y_2 as the variables,

$$(f_y^k, \phi_y^k)^k = (ab)^k a_x^{m-k} b_x^{n-k} = (f, \phi)^k;$$

or the k^{th} transvectant of the k^{th} polars, in regard to y, is equal to the k^{th} transvectant of the forms. Moreover, the k^{th} transvectant $(ab)^k a_x^{m-k} b_x^{n-k}$ is derivable from the k^{th} polar of a_x^m, viz., $a_x^{m-k} a_y^k$ by substituting for y_1, y_2 the cogredient quantities $b_2, -b_1$, and multiplying by b_x^{n-k}.

Frequently the forms to which the process is applied are, each of them, products of other forms.

Thus suppose

$$f = a_x^{m_1} b_x^{m_2},\ \phi = \alpha_x^{n_1} \beta_x^{n_2},$$

we find

$$\begin{aligned}(m_1+m_2)(n_1+n_2)&\left(a_x^{m_1} b_x^{m_2}, \alpha_x^{n_1} \beta_x^{n_2}\right)^1 \\ = m_1 n_1 (a\alpha) a_x^{m_1-1} b_x^{m_2} \alpha_x^{n_1-1} \beta_x^{n_2} &+ m_1 n_2 (a\beta) a_x^{m_1-1} b_x^{m_2} \alpha_x^{n_1} \beta_x^{n_2-1} \\ + m_2 n_1 (b\alpha) a_x^{m_1} b_x^{m_2-1} \alpha_x^{n_1-1} \beta_x^{n_2} &+ m_2 n_2 (b\beta) a_x^{m_1} b_x^{m_2-1} \alpha_x^{n_1} \beta_x^{n_2-1};\end{aligned}$$

where, on the dexter, there is a term for every pair of umbræ, one taken from f and one from ϕ. The sum of the numerical coefficients of the members of the transvectant is unity. If we suppose the product $a_x^{m_1} b_x^{m_2} \alpha_x^{n_1} \beta_x^{n_2}$ written out as a product of $m_1+m_2+n_1+n_2$ factors; the coefficient $(m_1+m_2)(n_1+n_2)$ enumerates the number of ways of picking out one factor from $a_x^{m_1} b_x^{m_2}$ and one factor from $\alpha_x^{n_1} \beta_x^{n_2}$; the coefficient $m_1 n_2$ on the dexter of the above results shows the number of ways of picking out one factor from $a_x^{m_1}$ and one from $\beta_x^{n_2}$; consequently the fraction $\frac{m_1 n_2}{(m_1+m_2)(n_1+n_2)}$, which affects one term of the transvectant, denotes the probability of picking out the pair $a_x \beta_x$ when a random selection is made of one factor from $a_x^{m_1} b_x^{m_2}$ and one factor from $\alpha_x^{n_1} \beta_x^{n_2}$. Similarly if

$$f = a_x^{m_1} b_x^{m_2} c_x^{m_3} \ldots s_x^{m_s},\ \phi = \alpha_x^{n_1} \beta_x^{n_2} \gamma_x^{n_3} \ldots \sigma_x^{n_\sigma},$$
$$\Sigma m = m,\ \Sigma n = n,$$

the first transvectant will consist of $s\sigma$ terms, and any term, involving say the determinant factor $(a\beta)$, will have a numerical coefficient which denotes the probability of a random selection of two factors, one each from f and ϕ, being $a_x \beta_x$. The sum of the coefficients is unity. Proceeding to the second transvectant each term is treated in a similar manner, with the result that a number of terms are obtained; one such term is, say

$$\frac{m_1 n_2 \,.\, m_1 - 1 \,.\, n_3}{m(m-1)n(n-1)} (a\beta)(a\gamma) a_x^{m_1-2} b_x^{m_2} \ldots \alpha_x^{n_1} \beta_x^{n_2-1} \gamma_x^{n_3-1} \ldots,$$

and the numerical coefficients denote the probability of two random selections of pairs of symbols yielding $(a\beta)(a\gamma)$, and so on. Hence, in general, the k^{th} transvectant involves terms, each of which has k determinant factors, and a numerical coefficient which denotes the probability of such factors arising from a random selection. Hence the sum of the coefficients of the terms must be unity.

Ex. gr.

$$\begin{aligned}(a_x b_x, c_x d_x)^1 &= \frac{1}{4}(ac) b_x d_x + \frac{1}{4}(ad) b_x c_x \\ &\quad + \frac{1}{4}(bc) a_x d_x + \frac{1}{4}(bd) a_x c_x; \\ (a_x b_x, c_x d_x)^2 &= \frac{1}{2}\{(ac)(bd) + (ad)(bc)\}.\end{aligned}$$

Ex. gr. We will find the fourth transvectant, of a binary quartic upon itself, so as to obtain the invariant $(ab)^4$ in terms of the roots of the quartic.

Let $a_x^4 = b_x^4 = (x_1 - \alpha_1 x_2)(x_1 - \alpha_2 x_2)(x_1 - \alpha_3 x_2)(x_1 - \alpha_4 x_2)$,

and observe that $(x_1 - \alpha_r x_2, x_1 - \alpha_s x_2)^1 = \alpha_r - \alpha_s$; therefore $(a_x^4, b_x^4)^1$ is a sum of a number of terms, each of which involves a factor of the form $\alpha_r - \alpha_s$, and proceeding we find $(a_x^4, b_x^4)^4$ equal to

$$\frac{1}{4!}\sum (\alpha_i - \alpha_1)(\alpha_j - \alpha_2)(\alpha_k - \alpha_3)(\alpha_l - \alpha_4),$$

the summation being for every permutation $ijkl$ of the numbers 1, 2, 3, 4. There are 4! terms, but certain of them vanish. Those which survive correspond to the permutations in which each number is displaced. These are nine in number, and we can, finally, throw the result into the form

$$\frac{1}{4!}\left\{(\alpha_1 - \alpha_2)(\alpha_3 - \alpha_4) + (\alpha_1 - \alpha_3)(\alpha_2 - \alpha_4) + (\alpha_1 - \alpha_4)(\alpha_2 - \alpha_3)\right\}^2;$$

a well-known expression of the simplest invariant of the binary quartic. It will be seen later that the coefficient $\bar{a}_0$ of every covariant of a binary form is a symmetric function of the differences of the roots of the forms.

The various transvectants can be obtained by partial differential operations in which the independent variables are $a_x, b_x, \ldots \alpha_x, \beta_x, \ldots$. Dropping, temporarily, the suffix x, we can see that

$$\left(a_x^{m_1} b_x^{m_2}, \alpha_x^{n_1} \beta_x^{n_2}\right)^1 \equiv \left(a^{m_1} b^{m_2}, \alpha^{n_1} \beta^{n_2}\right)^1$$

can be obtained by operating upon the product with

$$(a\alpha)\frac{d^2}{da\,d\alpha} + (a\beta)\frac{d^2}{da\,d\beta} + (b\alpha)\frac{d^2}{db\,d\alpha} + (b\beta)\frac{d^2}{db\,d\beta},$$

and multiplying by $\frac{1}{(m_1+m_2)(n_1+n_2)}$. Disregarding the multiplier we obtain the k^{th} transvectant by k successive operations of this operator, the quantities operated upon being $a = a_x$, $b = b_x$, ... and not the determinant factors. In general the operator is

$$\sum (a\alpha)\frac{d^2}{da\,d\alpha},$$

the number of terms in the operator being $s\sigma$, and k successive operations produce, to a factor *près*, the k^{th} transvectant.

Ex. gr. To find in this manner the second transvectant of $(ab)^2 a^{n-2} b^{n-2}$ upon itself, we take the product $(ab)^2 (cd)^2 a^{n-2} b^{n-2} c^{n-2} d^{n-2}$ and perform the operation

$$\left\{(ac)\frac{d^2}{da\,dc} + (ad)\frac{d^2}{da\,dd} + (bc)\frac{d^2}{db\,dc} + (bd)\frac{d^2}{db\,dd}\right\}^2,$$

when we obtain the result in the form of a linear function of the three forms:—

$$\begin{aligned}&(ab)^2 (ac)^2 (cd)^2 a^{n-4} b^{n-2} c^{n-4} d^{n-2},\\ &(ab)^2 (cd)^2 (ac)(ad) a^{n-4} b^{n-2} c^{n-3} d^{n-3},\\ &(ab)^2 (cd)^2 (ac)(bd) a^{n-3} b^{n-3} c^{n-3} d^{n-3}.\end{aligned}$$

A very important particular case of transvection is that in which $f = \mathrm{M} a_x^{m_1} b_x^{m_2} \ldots$, $\phi = g_x^n$; ϕ is the original form, f a covariant of ϕ, and M is the product of determinant factors involved in f. Writing for convenience

$$f = \mathrm{M} a^{m_1} b^{m_2} \ldots,\ \phi = g^n,$$

the operator, for the k^{th} transvectant, becomes effectively

$$\frac{1}{g^k}\left\{(ag)\frac{d}{da}+(bg)\frac{d}{db}+(cg)\frac{d}{dc}+\dots\right\}^k;$$

or if we take the operand to be f and not $f.g^n$ we may consider the operation

$$\left\{(ag)\frac{d}{da}+(bg)\frac{d}{db}+(cg)\frac{d}{dc}+\dots\right\}^k,$$

and disregard the factor g^{-k}.

We can transform the operator by expressing, by means of one of the fundamental identities, (bg), (cg), ... in terms of (ag) and determinant factors which are free from g. Thus

$$\begin{aligned}&(ag)\frac{d}{da}+(bg)\frac{d}{db}+(cg)\frac{d}{dc}+\dots\\&=\frac{1}{a}(ag)\left(a\frac{d}{da}+b\frac{d}{db}+c\frac{d}{dc}+\dots\right)\\&-\frac{g}{a}\left\{(ab)\frac{d}{db}+(ac)\frac{d}{dc}+\dots\right\}.\end{aligned}$$

Now

$$\left(a\frac{d}{da}+b\frac{d}{db}+c\frac{d}{dc}+\dots\right)f=mf,$$

where $m=m_1+m_2+m_3+\dots$; therefore the first transvectant is

$$\frac{1}{g}\frac{1}{a}(ag)mfg^n-\frac{1}{a}\mathrm{M}a^{m_1}g^n\left\{(ab)\frac{d}{db}+(ac)\frac{d}{dc}+\dots\right\}b^{m_2}c^{m_3}\dots,$$

an important form, because it shows that the transvectant can be broken up into two portions, in only one of which does the symbol g occur in the determinant factors. Conversely, if we have a form involving $m+1$ symbols in the determinant factors, in one of which g occurs only once, we may exhibit it by means of the transvectant of a form not involving g upon the original form, and of a form whose determinant factors involve only m symbols and do not involve g. This theorem is of great significance in the proof of Gordan's theorem concerning the finite number of covariants of a given form, and we must further generalize it. The operator for the second transvectant is

$$\left\{(ag)\frac{d}{da}+(bg)\frac{d}{db}+(cg)\frac{d}{dc}+\dots\right\}^2,$$

which may be written either as

$$\frac{1}{a^2}\left[(ag)\left(a\frac{d}{da}+b\frac{d}{db}+\dots\right)-g\left\{(ab)\frac{d}{db}+(ac)\frac{d}{dc}+\dots\right\}\right]^2,$$

or as

$$\begin{aligned}&\frac{1}{ab}\left[(ag)\left(a\frac{d}{da}+b\frac{d}{db}+\dots\right)-g\left\{(ab)\frac{d}{db}+(ac)\frac{d}{dc}+\dots\right\}\right]\\&\times\left[(bg)\left(a\frac{d}{da}+b\frac{d}{db}+\dots\right)-g\left\{(ba)\frac{d}{da}+(bc)\frac{d}{dc}+\dots\right\}\right].\end{aligned}$$

Taking the first form we find the second transvectant to be

$$m(m-1)\frac{1}{a^2}(ag)^2f.g^{n-2}$$

together with a number of terms in which (ag) occurs at most once. Hence a form, containing $m+1$ symbols and the $m+1^{th}$ symbol g only in the form $(ag)^2$, can be exhibited by means of the second transvectant of a form in m symbols over the original form and of a form which involves (ag) at most once; and now, combining the former result, we find that a form in $m+1$ symbols which involves the $m+1^{th}$ symbol g only in the form $(ag)^2$, can be expressed by means of forms involving m symbols, and by first and second transvectants of such a form upon the original form. The second form of operator above written leads to the same conclusion in regard to the factor $(ag)(bg)$. Similarly it is proved that a form in $m+1$ symbols which involves the determinant factors (ag), (bg), ... to the order k is expressible by means of forms in m symbols and 1st, 2nd, ... k^{th} transvectants of such forms upon the original forms.

Every symbolic product is expressible as a sum of transvectants. *Ex. gr.* Gordan takes as an example

$$\phi_x^3=(ab)^2(ac)^2(bc)^2a_xb_xc_x;$$

substituting for c_1, c_2 the cogredient variables $-y_2$, y_1 we obtain $(xy)(ab)^2a_xb_xa_y^2b_y^2$ which is a member of the fourth polar of $(ab)^2a_x^3b_x^3$ multiplied by (xy); putting $(ab)^2a_x^3b_x^3=\mathrm{G}_x^6=(ab)^2\mathrm{F}_x^6$ we find

$$a_xb_xa_y^2b_y^2=\left(\mathrm{F}_x^6\right)_y^4+\frac{2}{5}(xy)\left\{(ab)a_x^2b_x^2\right\}_y^3;$$

$$\therefore (ab)^2a_xb_xa_y^2b_y^2=\left(\mathrm{G}_x^6\right)_y^4+\frac{2}{5}(xy)\left(\mathrm{H}_x^4\right)_y^3,$$

where $\quad \mathrm{H}_x^4=(ab)^3a_x^2b_x^2.$

Now for y_1, y_2 write c_2, $-c_1$ and multiply by c_x.

$$\begin{aligned}\phi_x^3&=c_x\mathrm{G}_x^2(\mathrm{G}c)^4+\frac{2}{5}c_x^2\mathrm{H}_x(\mathrm{H}c)^3\\&=\left(\mathrm{G}_x^6,c_x^3\right)^4+\frac{2}{5}\left(\mathrm{H}_x^4,c_x^3\right)^3,\\&=\left\{(ab)^2a_x^3b_x^3,c_x^3\right\}^4+\frac{2}{5}\left\{(ab)^3a_x^2b_x^2,c_x^3\right\}^3;\end{aligned}$$

or if $a_x^3=b_x^3=c_x^3=f=f'=f''$, this is

$$\phi_x^3=\left\{(f,f')^2,f''\right\}^4+\frac{2}{5}\left\{(f,f')^3,f''\right\}^3.$$

In general it suffices to say that we transform one set of umbral symbols to a new set of variables, and make use as above of the properties of polars. The theorem establishes that transvectants are as inclusive as symbolic products in general.

First and Second Transvectants.—A few words must be said about the first two transvectants as they are of exceptional interest. Since, if $f=a_x^m$, $\phi=b_x^n$,

$$(f,\phi)^1=\frac{1}{mn}\left(\frac{\partial f}{\partial x_1}\frac{\partial\phi}{\partial x_2}-\frac{\partial f}{\partial x_2}\frac{\partial\phi}{\partial x_1}\right)=(ab)a_x^{m-1}b_x^{n-1}=\mathrm{J},$$

the first transvectant differs but by a numerical factor from the Jacobian or functional determinant, of the two forms. We can find an expression for the first transvectant of $(f,\phi)^1$ over another form c_x^p.

For

$$(m+n)(f,\phi)_y^1=nf.\phi_y^1+mf_y^1.\phi,$$

and

$$f.\phi_y^1-f_y.\phi=(a_xb_y-a_yb_x)a_x^{m-1}b_x^{n-1}=(xy)(f,\phi)^1;$$

$$\therefore (f,\phi)_y^1=f_y^1.\phi+\frac{n}{m+n}(xy)(f,\phi)^1.$$

Put $m-1$ for m, $n-1$ for n, and multiply through by (ab); then

$$\begin{aligned}\{(f,\phi)\}_y^1&=(ab)a_x^{m-2}a_yb_x^{n-1}+\frac{n-1}{m+n-2}(xy)(f,\phi)^2,\\&=(ab)a_x^{m-1}b_x^{n-2}b_y-\frac{m-1}{m+n-2}(xy)(f,\phi)^2.\end{aligned}$$

Multiply by c_x^{p-1} and for y_1, y_2 write c_2, $-c_1$; then the right-hand side becomes

$$(ab)(bc)a_x^{m-1}b_x^{n-2}c_x^{p-1}+\frac{m-1}{m+n-2}c_x^p(f,\phi)^2,$$

of which the first term, writing $c_x^p=\psi$, is

$$\begin{aligned}&a_x^{m-2}b_x^{n-2}c_x^{p-2}(ab)(bc)a_xc_x\\&=-\frac{1}{2}a_x^{m-2}b_x^{n-2}c_x^{p-2}\left\{(bc)^2a_x^2+(ab)^2c_x^2-(ac)^2b_x^2\right\}\\&=-\frac{1}{2}\left\{a_x^m(bc)^2b_x^{n-2}c_x^{p-2}+c_x^p(ab)^2a_x^{m-2}b_x^{n-2}-b_x^n(ac)^2a_x^{m-2}c_x^{p-2}\right\}\\&=-\frac{1}{2}\left\{(\phi,\psi)^2.f+(f,\phi)^2.\psi-(f,\psi)^2.\phi\right\};\end{aligned}$$

and, if $(f,\phi)^1=k_x^{m+n-2}$,

$$\left\{(f,\phi)^1\right\}_y^1.c_x^{p-1}=k_x^{m+n-2}k_yc_x^{p-1};$$

and this, on writing c_2, $-c_1$ for y_1, y_2, becomes

$$(kc)k_x^{m+n-2}c_x^{p-1}=\left\{(f,\phi)^1,\psi\right\}^1;$$

$$\therefore \{(f,\phi)^1,\psi\}^1=\frac{1}{2}\left\{\frac{m-n}{m+n-2}(f,\phi)^2.\psi+(f,\psi)^2.\phi-(\phi,\psi)^2.f\right\};$$

and thence it appears that the first transvectant of $(f,\phi)^1$ over ψ is always expressible by means of forms of lower degree in the coefficients wherever each of the forms f, ϕ, ψ is of higher degree than the first in x_1, x_2.

The second transvectant of a form over itself is called the Hessian of the form. It is

$$(f,f')^2=(ab)^2a_x^{m-2}b_x^{m-2}=\mathrm{H}_x^{2m-4}=\mathrm{H};$$

unsymbolically it is a numerical multiple of the determinant $\frac{\partial^2f}{\partial x_1^2}\frac{\partial^2f}{\partial x_2^2}-\left(\frac{\partial^2f}{\partial x_1\partial x_2}\right)^2$. It is also the first transvectant of the differential coefficients of the form with regard to the variables, viz., $\left(\frac{\partial f}{\partial x_1},\frac{\partial f}{\partial x_2}\right)^1$. For the quadratic it is the discriminant $(ab)^2$ and for the cubic the quadratic covariant $(ab)^2a_xb_x$.

In general for a form in n variables the Hessian is

$$\begin{vmatrix} \frac{\partial^2 f}{\partial x_1^2} & \frac{\partial^2 x}{\partial x_1 \partial x_2} & \cdots & \frac{\partial^2 f}{\partial x_1 \partial x_n} \\ \frac{\partial^2 f}{\partial x_1 \partial x_2} & \frac{\partial^2 f}{\partial x_2^2} & \cdots & \frac{\partial^2 f}{\partial x_2 \partial x_n} \\ \vdots & \vdots & & \vdots \\ \frac{\partial^2 f}{\partial x_1 \partial x_n} & \frac{\partial^2 f}{\partial x_2 \partial x_n} & \cdots & \frac{\partial^2 f}{\partial x_n^2} \end{vmatrix} = \mathrm{H}_x^{n(n-2)} = \mathrm{H}\,;$$

and there is a remarkable theorem which states that if $\mathrm{H}=0$ and $n=2, 3$, or 4 the original form can be exhibited as a form in 1, 2, 3 variables respectively.

Ex. gr. If $(ab)^2 a_x^{m-2} b_x^{m-2}=0$, for the binary form a_x^m, the theorem states that the form is a simple m^{th} power $(a_1 x_1 + a_2 x_2)^m$, and therefore, by linear transformation, depends only on a single variable.

It may be verified that, if $a_x^m = f$,

$$\frac{1}{2}(xy)^2 \mathrm{H} = f . f_y^2 - \left(f_y^1\right)^2\,;$$

and now assuming f to have the form $a_x^\rho . \phi_x^\sigma$ where a_x is a linear form and ϕ_x^σ a form of order σ; $\rho+\sigma=m$,

$$f_y^1 = \frac{\rho}{m} a_x^{\rho-1} a_y \phi_x^\sigma + \frac{\sigma}{m} a^\rho \phi_x^{\sigma-1} \phi_y,$$

$$m(m-1) f_y^2 = \rho(\rho-1) a_x^{\rho-2} a_y^2 \phi_x^\sigma + 2\rho\sigma a_x^{\rho-1} a_y \phi_x^{\sigma-1} \phi_y$$
$$+ \sigma(\sigma-1) a_x^\rho \phi_x^{\sigma-2} \phi_y^2,$$

leading to

$$0 = m^2(m-1)\left\{f . f_y^2 - \left(f_y^1\right)^2\right\}$$
$$= \left\{m\rho(\rho-1) - (m-1)\rho^2\right\} a_x^{2\rho-2} a_y^2 \phi^2$$
$$+ 2\rho\sigma a_x^{2\rho-1} a_y \phi_y^1 . \phi + \left\{m\sigma(\sigma-1)\phi_y \phi - (m-1)\sigma^2\left(\phi_y^1\right)^2\right\} a_x^{2\rho}\,;$$

and, since each term on the right must vanish separately, $m=\rho$, $\sigma=0$, which proves the theorem.

It has been established above that every symbolic product can be expressed by means of transvectants. We have now to show that every invariant can be expressed by means of symbolic products. It suffices to prove this for invariants as will appear.

When an invariant is expressed in terms of the umbræ a_1, a_2; b_1, b_2; c_1, c_2;... it is homogeneous and of weight w in the series of symbols $a_1, b_1, c_1, \ldots$ and also in the series $a_2, b_2, c_2, \ldots$. Let then an invariant j of weight w be written symbolically

$$j = (s_1 a_1 + s_2 b_1 + s_3 c_1 + \ldots)^w (t_1 a_2 + t_2 b_2 + t_3 c_2 + \ldots)^w\,;$$

transforming, by linear substitution, $\mathrm{J}=(\lambda\mu)^w j$; or

$$\mathrm{J} = (s_1 a_\lambda + s_2 b_\lambda + s_3 c_\lambda + \ldots)^w (t_1 a_\mu + t_2 b_\mu + t_3 c_\mu + \ldots)^w$$
$$= \{(s_1 a_1 + s_2 b_1 + s_3 c_1 + \ldots)\lambda_1 + (s_1 a_2 + s_2 b_2 + s_3 c_2 + \ldots)\lambda_2\}^w$$
$$\times \{(t_1 a_1 + t_2 b_1 + t_3 c_1 + \ldots)\mu_1 + (t_1 a_2 + t_2 b_2 + t_3 c_2 + \ldots)\mu_2\}^w$$
$$= (p_1 \lambda_1 + p_2 \lambda_2)^w (q_1 \mu_1 + q_2 \mu_2)^w = p_\lambda^w q_\mu^w,$$

where

$$p_1 = s_1 a_1 + s_2 b_1 + s_3 c_1 + \ldots,$$
$$p_2 = s_1 a_2 + s_2 b_2 + s_3 c_2 + \ldots,$$
$$q_1 = t_1 a_1 + t_2 b_1 + t_3 c_1 + \ldots,$$
$$q_2 = t_1 a_2 + t_2 b_2 + t_3 c_2 + \ldots,$$

and

$$(pq) = p_1 q_2 - p_2 q_1,$$
$$= s_1 t_2 (ab) + s_1 t_3 (ac) + \ldots + s_2 t_3 (bc) + \ldots\,;$$

now, since $p_\lambda^w q_\mu^w = (\lambda\mu)^w j$, if we operate with

$$\frac{\partial^2}{\partial\lambda_1 \partial\mu_2} - \frac{\partial^2}{\partial\lambda_2 \partial\mu_1}$$

we obtain

$$w^2 (pq) p_\lambda^{w-1} q_\mu^{w-1} = w(w+1)(\lambda\mu)^{w-1} j,$$

or

$$\frac{w}{w+1}(pq) p_\lambda^{w-1} q_\mu^{w-1} = (\lambda\mu)^{w-1} j\,;$$

again operating

$$\frac{w-1}{w+1}(pq)^2 p_\lambda^{w-2} q_\mu^{w-2} = (\lambda\mu)^{w-2} j\,;$$

and continuing to operate we arrive at

$$j = \frac{1}{w+1}(pq)^w,$$
$$= \frac{1}{w+1}\{s_1 t_2 (ab) + s_1 t_3 (ac) + \ldots + s_2 t_3 (bc) + \ldots\}^w\,;$$

establishing that the invariant j is expressible as a sum of symbolic products, each product involving w determinant factors.

The Form $f+\lambda\phi$.—An important method for the formation of covariants is connected with the form $f+\lambda\phi$, where f and ϕ are of the same order in the variables and λ is an arbitrary constant. If the invariants and covariants of this composite quantic be formed we obtain functions of λ such that the coefficients of the various powers of λ are simultaneous invariants of f and ϕ. In particular, when ϕ is a covariant of f, we obtain in this manner covariants of f. Consider, for example, the cubic

$$f = a_x^3,$$

and take for ϕ its cubic covariant

$$\mathrm{Q} = (ab)^2 (cb) c_x^2 a_x.$$

If J be any covariant of f, denote by $\mathrm{J}_{f+\lambda\mathrm{Q}}$ the corresponding covariant of $f+\lambda\mathrm{Q}$. There are four fundamental covariants of f, viz. :—

$$f = a_x^3,$$
$$\Delta = (f, f')^2 = (ab)^2 a_x b_x,$$
$$\mathrm{Q} = (f, \Delta)^1 = (ab)^2 (cb) c_x^2 a_x,$$
$$\mathrm{R} = (\Delta, \Delta')^2 = (ab)^2 (cd)^2 (ac)(bd).$$

To find the fundamental system of $f+\lambda\mathrm{Q}$ we have

$$f_{f+\lambda\mathrm{Q}} = f + \lambda\mathrm{Q},$$
$$\Delta_{f+\lambda\mathrm{Q}} = (f+\lambda\mathrm{Q}, f+\lambda\mathrm{Q})^2,$$
$$= (f f')^2 + 2\lambda(f, \mathrm{Q})^2 + \lambda^2(\mathrm{Q}, \mathrm{Q}')^2.$$

To reduce this expression take the first polar of $\Delta = \Delta_x^2$,

$$2\Delta_x \Delta_y = (ab)^2 a_x b_y + (ab)^2 a_y b_x,$$

or

$$\Delta_x \Delta_y = (ab)^2 a_x b_y.$$

Herein, Δ_1, Δ_2' being symbols equivalent to Δ_1, Δ_2, substitute Δ_1, Δ_2' for $-x_2, x_1$ and multiply by Δ_y', so that

$$(\Delta\Delta')\Delta_y \Delta_y' = (ab)^2 (a\Delta') b_y \Delta_y'.$$

Now

$$\mathrm{Q}_x^3 = (f, \Delta)^1 = (a\Delta) a_x^2 \Delta_x,$$
$$3\mathrm{Q}^2 \mathrm{Q}_y = (a\Delta)(a_x^2 \Delta_y + 2a_x a_y \Delta_x),$$
$$= (a\Delta)\left\{3a_x^2 \Delta_y + 2a_x(a_y \Delta_x - a_x \Delta_y)\right\}$$
$$= 3(a\Delta) a_x^2 \Delta_y + 2(xy)(a\Delta)^2 a_x\,;$$

and, since it is easy to see that $(f, \Delta)^2 = (a\Delta)^2 a_x$ vanishes identically,

$$\mathrm{Q}_x^2 \mathrm{Q}_y = (a\Delta) a_x^2 \Delta_y\,;$$

and, herein writing $b_2, -b_1$ for x_1, x_2,

$$(b\mathrm{Q})^2 \mathrm{Q}_y = (a\Delta)(ab)^2 \Delta_y\,;$$

or

$$(b\mathrm{Q})^2 b_x \mathrm{Q}_x = (a\Delta)(ab)^2 b_x \Delta_x,$$
$$= (\Delta\Delta')\Delta_x \Delta_x' = (\Delta, \Delta')^1\,;$$
$$\therefore (f, \mathrm{Q})^2 = 0.$$

Again, since

$$\mathrm{Q}_x^2 \mathrm{Q}_y = (a\Delta) a_x^2 \Delta_y,$$

substituting $\mathrm{Q}_2', -\mathrm{Q}_1'$ for x_1, x_2,

$$(\mathrm{Q}\mathrm{Q}')^2 \mathrm{Q}_y \mathrm{Q}_y' = (a\Delta)(a\mathrm{Q})^2 \Delta_y \mathrm{Q}_y.$$

But

$$(f, \mathrm{Q})^2 = (a\mathrm{Q})^2 a_x \mathrm{Q}_x = 0,$$
$$\therefore (a\mathrm{Q})^2 (a_x \mathrm{Q}_y + a_y \mathrm{Q}_x) = 0,$$

and

$$(a\mathrm{Q})^2 (a_x \mathrm{Q}_y - a_y \mathrm{Q}_x) = (a\mathrm{Q})^3 (xy)\,;$$

$\therefore$, by addition,

$$(a\mathrm{Q})^2 a_x \mathrm{Q}_y = \frac{1}{2}(a\mathrm{Q})^3 (xy)\,;$$
$$\therefore (a\Delta)(a\mathrm{Q})^2 \Delta_y \mathrm{Q}_y = \frac{1}{2}(a\mathrm{Q})^3 \Delta_y^2 = \frac{1}{2}\mathrm{R} . \Delta_y^2.$$

since it is quite easy to show that $(a\mathrm{Q})^3 = (\Delta, \Delta')^2$,

$$\therefore (\mathrm{Q}, \mathrm{Q}')^2 = \frac{1}{2}\mathrm{R} . \Delta\,;$$

and finally

$$\Delta_{f+\lambda\mathrm{Q}} = \Delta + \lambda^2 . \frac{1}{2}\mathrm{R} . \Delta.$$

Similarly

$$\mathrm{Q}_{f+\lambda\mathrm{Q}} = (f+\lambda\mathrm{Q}, \Delta + \frac{1}{2}\lambda^2 \mathrm{R}\Delta)^1,$$
$$= (f, \Delta)^1 + \lambda(\mathrm{Q}, \Delta)^1 + \frac{1}{2}\lambda^2 \mathrm{R}(f, \Delta)^1 + \frac{1}{2}\lambda^3 \mathrm{R}(\mathrm{Q}, \Delta)^1,$$

wherein $(f, \Delta)^1 = \mathrm{Q}$, and we have to reduce $(\mathrm{Q}, \Delta)^1$.

From

$$Q_x^2Q_y=(a\Delta)a_x^2\Delta_y,$$

we obtain, substituting $+\Delta_2, -\Delta_1$ for y_1, y_2,

$$(Q\Delta)Q_x^2\Delta_x=(a\Delta)(\Delta\Delta')a_x^2\Delta'_x,$$

or

$$(Q,\Delta)^1=\frac{1}{2}(\Delta\Delta')a_x^2\left\{(a\Delta)\Delta'_x-(a\Delta')\Delta_x\right\},$$

$$=-\frac{1}{2}(\Delta\Delta')^2a_x^2=-\frac{1}{2}R.f;$$

$$\therefore Q_{f+\lambda Q}=Q\left(1+\frac{1}{2}\lambda^2R\right)-\frac{1}{2}Rf\left(\lambda+\frac{1}{2}\lambda^3R\right),$$

$$=\left(1+\frac{1}{2}\lambda^2R\right)\left(Q-\frac{1}{2}\lambda R.f\right).$$

So also it may be shown that

$$R_{f+\lambda Q}=R+\lambda^2R^2+\frac{1}{4}\lambda^4R^3.$$

In general, if $f=a_x^m, \phi=\alpha_x^n$, be any two forms, and any invariant of f be $j=\theta(\bar{a}_0, \bar{a}_1, \ldots \bar{a}_m)$, the corresponding invariant of $f+\lambda\phi$, viz.:

$$j_{f+\lambda\phi}=\theta(\bar{a}_0+\lambda\bar{\alpha}_0, \bar{a}_1+\lambda\bar{\alpha}_1, \ldots \bar{a}_m+\lambda\bar{\alpha}_m)$$

$$=e^{\lambda\delta}j,$$

where

$$\delta=\bar{\alpha}_0\frac{\partial}{\partial\bar{a}_0}+\bar{\alpha}_1\frac{\partial}{\partial\bar{a}_1}+\ldots+\bar{\alpha}_m\frac{\partial}{\partial\bar{a}_m}.$$

Now, if j be of degree ν in the coefficients $\bar{a}$, it is a homogeneous function, and may be denoted symbolically by

$$p_a^\nu=(p_0a_0+p_1a_1+\ldots+p_ma_m)^\nu,$$

involving $m+1$ umbrae.

Thence

$$j_{f+\lambda\phi}=e^{\lambda\delta}j=(p_a+\lambda p_\alpha)^\nu=\sum_k\binom{\nu}{k}p_a^{\nu-k}p_\alpha^k\lambda^k;$$

and, comparison of the coefficients of λ^k, gives

$$\frac{1}{k!}(\delta^k)j=\binom{\nu}{k}p_a^{\nu-k}p_\alpha^k=\binom{\nu}{k}(p_a^\nu)_\alpha^k=\binom{\nu}{k}j_\alpha^k,$$

which is simply a numerical multiple of the k^{th} α-polar of j. It must be noticed that (δ^k) denotes an operator of order k, and that it is only equivalent to k successive operations of δ in the particular case when the coefficients $\bar{\alpha}_0, \bar{\alpha}_1, \ldots$ are independent of the coefficients $\bar{a}_0, \bar{a}_1, \ldots$. The operation of δ upon a symbolic product is very simple; suppose Δ to be a symbol which occurs in the product; it may present itself in a determinant factor say $(\Delta\rho)$, or in a power form Δ_x^p. If we find $\delta\Delta_x^m=\psi_x^m$ we write ψ for Δ wherever Δ occurs, and thus obtain one term in the result of the operation; the complete result is obtained by summation in regard to all the symbols dealt with in this manner. The operation of δ upon a transvectant, expressed as such, is precisely similar.

Ex. gr. Let $F_1=(ab)^2(ac)^2(bc)^2$,

where $f=a_x^4, \phi=\alpha_x^4$,

and $\delta a_x^4=\delta b_x^4=\delta c_x^4=\alpha_x^4$;

then

$$\delta F_1=(\alpha b)^2(\alpha c)^2(bc)^2+(a\alpha)^2(ac)^2(\alpha c)^2+(ab)^2(a\alpha)^2(b\alpha)^2,$$
$$=3(ab)^2(a\alpha)^2(b\alpha)^2.$$

Again let $F_2=\{(f,f')^2,f''\}^4$,
where $\delta f=\delta f'=\delta f''=\phi$;
then

$$\delta F_2=\{(\phi,f')^2,f''\}^4+\{(f,\phi)^2f''\}^4+\{(f,f')^2,\phi\}^4,$$
$$=3\{(f,f')^2,\phi\}^4.$$

So far we may always go whatever the values of $\bar{\alpha}_0, \bar{\alpha}_1\ldots$; but when these are independent of $\bar{a}_0, \bar{a}_1, \ldots$ we may introduce new symbols and obtain

$$\delta^2F_1=3(\beta b)^2(\beta\alpha)^2(b\alpha)^2+3(\alpha\beta)^2(a\alpha)^2(\beta a)^2,$$
$$=6(\alpha\beta)^2(a\alpha)^2(a\beta)^2;$$
$$\delta^3F_1=6(\gamma\beta)^2(\gamma\alpha)^2(\alpha\beta)^2;$$

so that $e^{\lambda\delta}F_1$

$$=(ab)^2(ac)^2(bc)^2+3(ab)^2(a\alpha)^2(b\alpha)\lambda^2.$$
$$+3(\alpha\beta)^2(a\alpha)^2(a\beta)^2\lambda^2+(\beta\gamma)^2(\alpha\gamma)^2(\alpha\beta)^2\lambda^3.$$

Also

$$\delta^2F_2=3\{(\phi',f')^2,\phi\}^4+3\{(f,\phi')^2,\phi\}^4,$$
$$=6\{(\phi,\phi')^2,f\}^4;$$
$$\delta^3F_2=6\{(\phi,\phi')^2,\phi''\}^4;$$

leading to

$$e^{\lambda\delta}F_2=\{(f,f')^2,f''\}^4+3\{(f,f')^2,\phi\}^4\lambda$$
$$+3\{(\phi,\phi')^2f\}^4\lambda^2+\{(\phi,\phi')^2,\phi''\}^4\lambda^3.$$

When, on the other hand, $\bar{\alpha}_0, \bar{\alpha}_1, \ldots$ are functions of $\bar{a}_0, \bar{a}_1, \ldots$ the matter is not so simple, for now (δ^k) an operator of order k is not equivalent to δ^k, k successive operations of δ. Write $\delta=\delta_1$; then $\delta_1^2=(\delta_1^2)+\delta_1\dagger\delta_1$ when $\delta_1\dagger\delta_1$ is an operator formed by operating upon δ_1 with δ_1 regarding the former merely as a function of $\bar{a}_0, \bar{a}_1, \ldots$; so that

$$\delta_1\dagger\delta_1=(\delta_1\bar{\alpha}_0)\frac{d}{d\bar{a}_0}+(\delta_1\bar{\alpha}_1)\frac{d}{d\bar{a}_1}+\ldots;$$

write $\delta_1\dagger\delta_1=\delta_2$, and generally $\delta_1\dagger\delta_s=\delta_{s+1}$, then it is easy to show that

$$\frac{1}{2!}(\delta_1^2)=\frac{1}{2!}(\delta_1^2-\delta_2),$$

$$\frac{1}{3!}(\delta_1^3)=\frac{1}{3!}(\delta_1^3-3\delta_1\delta_2+2\delta_3),$$

according to a well-known law established by the theorem of operator-transformation given in the section on symmetric functions.

The Partial Differential Equations.—It will be shown later that covariants may be studied by restricting attention to the leading coefficient, viz., that affecting x_1^ϵ where ϵ is the order of the covariant. An important fact, discovered by Cayley, is that these coefficients, and also the complete covariants, satisfy certain partial differential equations which suffice to determine them, and to ascertain many of their properties. These equations can be arrived at in many ways; the method here given is due to Gordan. $\lambda_1, \lambda_2, \mu_1, \mu_2$ being as usual the coefficients of substitution, let

$$\lambda_1\frac{\partial}{\partial\lambda_1}+\lambda_2\frac{\partial}{\partial\lambda_2}=D_{\lambda\lambda}, \lambda_1\frac{\partial}{\partial\mu_1}+\lambda_2\frac{\partial}{\partial\mu_2}=D_{\lambda\mu},$$

$$\mu_1\frac{\partial}{\partial\lambda_1}+\mu_2\frac{\partial}{\lambda_2}=D_{\mu\lambda}, \mu_1\frac{\partial}{\partial\mu_1}+\mu_2\frac{\partial}{\partial\mu_2}=D_{\mu\mu},$$

be linear operators. Then if j, J be the original and transformed forms of an invariant

$$J=(\lambda\mu)^wj,$$

w being the weight of the invariant.

Operation upon J results as follows:—

$$D_{\lambda\lambda}J=wJ; D_{\lambda\mu}J=0;$$

$$D_{\mu\lambda}J=0; D_{\mu\mu}J=wJ.$$

The first and fourth of these indicate that $(\lambda\mu)^w$ is a homogeneous function of λ_1, λ_2, and of μ_1, μ_2 separately, and the second and third arise from the fact that $(\lambda\mu)$ is caused to vanish by both $D_{\lambda\mu}$ and $D_{\mu\lambda}$.

Since $J=F(\bar{A}_0, \bar{A}_1, \ldots \bar{A}_k, \ldots)$, where $\bar{A}_k=a_\lambda^{n-k}a_\mu^k$,

we find that the results are equivalent to

$$\sum_k(D_{\lambda\lambda}\bar{A}_k)\frac{\partial J}{\partial\bar{A}_k}=wJ; \sum_k(D_{\lambda\mu}\bar{A}_k)\frac{\partial J}{\partial\bar{A}_k}=0;$$

$$\sum_k(D_{\mu\lambda}\bar{A}_k)\frac{\partial J}{\partial\bar{A}_k}=0; \sum_k(D_{\mu\mu}\bar{A}_k)\frac{\partial J}{\partial\bar{A}_k}=wJ.$$

According to the well-known law for the changes of independent variables. Now

$$D_{\lambda\lambda}\bar{A}_k=(n-k)\bar{A}_k; D_{\lambda\mu}\bar{A}_k=k\bar{A}_{k-1};$$

$$D_{\mu\lambda}\bar{A}_k=(n-k)\bar{A}_{k+1}; D_{\mu\mu}\bar{A}_k=k\bar{A}_k;$$

so we obtain

$$\sum_k(n-k)\bar{A}_k\frac{\partial J}{\partial\bar{A}_k}=wJ; \sum_k k\bar{A}_{k-1}\frac{\partial J}{\partial\bar{A}_k}=0;$$

$$\sum_k(n-k)\bar{A}_{k+1}\frac{\partial J}{\partial\bar{A}_k}=0; \sum_k k\bar{A}_k\frac{\partial J}{\partial\bar{A}_k}=wJ;$$

equations which are valid when $\lambda_1, \lambda_2, \mu_1, \mu_2$ have arbitrary values, and therefore when the values are such that $J=j$, $\bar{A}_k=\bar{a}_k$.

Hence

$$n\bar{a}_0\frac{\partial j}{\partial\bar{a}_0}+(n-1)\bar{a}_1\frac{\partial j}{\partial\bar{a}_1}+(n-2)\bar{a}_2\frac{\partial j}{\partial\bar{a}_2}+\ldots=wj,$$

$$\bar{a}_0\frac{\partial j}{\partial\bar{a}_1}+2\bar{a}_1\frac{\partial j}{\partial\bar{a}_2}+3\bar{a}_2\frac{\partial j}{\partial\bar{a}_3}+\ldots=0,$$

$$n\bar{a}_1\frac{\partial j}{\partial\bar{a}_0}+(n-1)\bar{a}_2\frac{\partial j}{\partial\bar{a}_1}+(n-2)\bar{a}_3\frac{\partial j}{\partial\bar{a}_2}+\ldots=0,$$

$$\bar{a}_1\frac{\partial j}{\partial\bar{a}_1}+2\bar{a}_2\frac{\partial j}{\partial\bar{a}_2}+3\bar{a}_3\frac{\partial j}{\partial\bar{a}_3}+\ldots=wj,$$

the complete system of equations satisfied by an invariant. The fourth shows that every term of the invariant is of the same weight. Moreover, if we add the first to the fourth we obtain

$$\sum_k \bar a_k \frac{\partial j}{\partial a_k} = \frac{2w}{n} j = \theta j,$$

where θ is the degree of the invariant; this shows, as we have before observed, that for an invariant

$$w = \frac{1}{2} n\theta.$$

The second and third are those upon the solution of which the theory of the invariant may be said to depend. An instantaneous deduction from the relation $w = \frac{1}{2}n\theta$ is that forms of uneven orders possess only invariants of even degree in the coefficients. The two operators

$$\Omega = \bar a_0 \frac{\partial}{\partial a_1} + 2\bar a_1 \frac{\partial}{\partial a_2} + \dots + n\bar a_{n-1} \frac{\partial}{\partial a_n}$$

$$O = n\bar a_1 \frac{\partial}{\partial a_0} + (n-1)\bar a_2 \frac{\partial}{\partial a_1} + \dots + \bar a_n \frac{\partial}{\partial a_{n-1}}$$

have been much studied by Sylvester, Hammond, Hilbert, and Elliott (Elliott, *l.c.* ch. vi.) It has been established that, if $F(\bar a_0, \bar a_1, \dots \bar a_n)$ be *any* rational, integral, homogeneous, and isobaric function of the coefficients,

$$F(\bar A_0, \bar A_1, \dots \bar A_n)$$
$$= (\lambda\mu)^w \lambda_1^{n\theta-2w} exp\left\{\frac{\lambda_2}{\lambda_1} O + \frac{\lambda_1\mu_1}{(\lambda\mu)}\Omega\right\} F(\bar a_0, \bar a_1, \dots \bar a_n),$$

a result from which all the important facts concerning invariants may be deduced.

The analogous partial differential equations satisfied by any covariant j may be established as follows. We have

$$J = (\lambda\mu)^{w+\epsilon} j$$

where
$$J = F\{\bar A_0, \bar A_1, \dots (x\mu), (\lambda x)\}$$
$$j = F(\bar a_0, \bar a_1, \dots x_1, x_2)$$

the new variables being $\xi_1 = (x\mu) = \quad \mu_2 x_1 - \mu_1 x_2$
$\xi_2 = (\lambda x) = -\lambda_2 x_1 + \lambda_1 x_2.$

We then obtain

$$\sum_k (D_{\lambda\lambda}\bar A_k)\frac{\partial J}{\partial A_k} + (D_{\lambda\lambda}\xi_2)\frac{\partial J}{\partial \xi_2} = (w+\epsilon)J,$$

$$\sum_k (D_{\lambda\mu}\bar A_k)\frac{\partial J}{\partial A_k} + (D_{\lambda\mu}\xi_1)\frac{\partial J}{\partial \xi_1} = 0,$$

$$\sum_k (D_{\mu\lambda}\bar A_k)\frac{\partial J}{\partial A_k} + (D_{\mu\lambda}\xi_2)\frac{\partial J}{\partial \xi_2} = 0,$$

$$\sum_k (D_{\mu\mu}\bar A_k)\frac{\partial J}{\partial A_k} + (D_{\mu\mu}\xi_1)\frac{\partial J}{\partial \xi_1} = (w+\epsilon)J;$$

or

$$\sum_k (n-k)\bar A_k \frac{\partial J}{\partial A_k} + \xi_2 \frac{\partial J}{\partial \xi_2} = (w+\epsilon)J,$$

$$\sum_k k\bar A_{k-1} \frac{\partial J}{\partial A_k} - \xi_2 \frac{\partial J}{\partial \xi_1} = 0,$$

$$\sum_k (n-k)\bar A_{k+1} \frac{\partial J}{\partial A_k} - \xi_1 \frac{\partial J}{\partial \xi_2} = 0,$$

$$\sum_k k\bar A_k \frac{\partial J}{\partial A_k} + \xi_1 \frac{\partial J}{\partial \xi_1} = (w+\epsilon)J.$$

Now, as before, we pass from J to j; further, we make use of the formula

$$\xi_1 \frac{\partial j}{\partial \xi_1} + \xi_2 \frac{\partial j}{\partial \xi_2} = \epsilon j,$$

and we obtain

$$n\bar a_0 \frac{\partial j}{\partial a_0} + (n-1)\bar a_1 \frac{\partial j}{\partial a_1} + \dots - x_1 \frac{\partial j}{\partial x_1} = wj,$$

$$\bar a_0 \frac{\partial j}{\partial a_1} + 2\bar a_1 \frac{\partial j}{\partial a_2} + \dots - x_2 \frac{\partial j}{\partial x_1} = 0,$$

$$n\bar a_1 \frac{\partial j}{\partial a_0} + (n-1)\bar a_2 \frac{\partial j}{\partial a_1} + \dots - x_1 \frac{\partial j}{\partial x_2} = 0,$$

$$\bar a_1 \frac{\partial j}{\partial a_1} + 2\bar a_2 \frac{\partial j}{\partial a_2} + \dots - x_2 \frac{\partial j}{\partial x_2} = wj;$$

the complete system.

Adding the first and fourth equations we obtain

$$n\theta - \epsilon = 2w,$$

the invariant relation connecting the four numbers n, θ, ϵ, w. The satisfaction of the differential equations is not only necessary, but it is also sufficient. To establish this, in the case of invariants let J be any solution of the differential equations, in which the quantities $\bar A_k$ are independent variables, and K any other solution. We obtain

$$\frac{1}{K^2}\left(K\frac{\partial J}{\partial \lambda_1} - J\frac{\partial K}{\partial \lambda_1}\right)\lambda_1 + \frac{1}{K^2}\left(K\frac{\partial J}{\partial \lambda_2} - J\frac{\partial K}{\partial \lambda_2}\right)\lambda_2 = 0,$$

$$\frac{1}{K^2}\left(K\frac{\partial J}{\partial \mu_1} - J\frac{\partial K}{\partial \mu_1}\right)\lambda_1 + \frac{1}{K^2}\left(K\frac{\partial J}{\partial \mu_2} - J\frac{\partial K}{\partial \mu_2}\right)\lambda_2 = 0,$$

$$\frac{1}{K^2}\left(K\frac{\partial J}{\partial \lambda_1} - J\frac{\partial K}{\partial \lambda_1}\right)\mu_1 + \frac{1}{K^2}\left(K\frac{\partial J}{\partial \lambda_2} - J\frac{\partial K}{\partial \lambda_2}\right)\mu_2 = 0,$$

$$\frac{1}{K^2}\left(K\frac{\partial J}{\partial \mu_1} - J\frac{\partial K}{\partial \mu_1}\right)\mu_1 + \frac{1}{K^2}\left(K\frac{\partial J}{\partial \mu_2} - J\frac{\partial K}{\partial \mu_2}\right)\mu_2 = 0;$$

or, if $J = KL$,

$$\frac{\partial L}{\partial \lambda_1}\lambda_1 + \frac{\partial L}{\partial \lambda_2}\lambda_2 = 0; \frac{\partial L}{\partial \mu_1}\lambda_1 + \frac{\partial L}{\partial \mu_2}\lambda_2 = 0;$$
$$\frac{\partial L}{\partial \lambda_1}\mu_1 + \frac{\partial L}{\partial \lambda_2}\mu_2 = 0; \frac{\partial L}{\partial \mu_1}\mu_1 + \frac{\partial L}{\partial \mu_2}\mu_2 = 0.$$

As $(\lambda\mu)$ does not vanish, these equations necessitate

$$\frac{\partial L}{\partial \lambda_1} = 0, \frac{\partial L}{\partial \mu_1} = 0, \frac{\partial L}{\partial \lambda_2} = 0, \frac{\partial L}{\partial \mu_2} = 0,$$

showing that L is independent of λ_1, λ_2, μ_1, μ_2.

We may put $K = (\lambda\mu)^w$ so that

$$J = (\lambda\mu)^w L$$

and now putting $\lambda_1 = \mu_2 = 1$, $\lambda_2 = \mu_1 = 0$, L becomes equal to j, and $J = (\lambda\mu)^w j$; hence this relation is satisfied by every solution j of the differential equations. If we have several binary quantics we have similarly the two operations

$$\sum \Omega - x_2 \frac{\partial}{\partial x_1},$$
$$\sum O - x_1 \frac{\partial}{\partial x_2},$$

which cause the vanishing of a covariant and the invariable relation

$$\Sigma n\theta - 2w = \epsilon$$

connecting the numbers n_1, θ_1, n_2, θ_2, ... w, ϵ.

The Evectant Process.—If we have a symbolic product, which contains the symbol a only in determinant factors such as (ab), we may write $x_2, -x_1$ for a_1, a_2, and thus obtain a product in which (ab) is replaced by b_x, (ac) by c_x and so on. In particular, when the product denotes an invariant we may transform each of the symbols a, b, ... to x in succession, and take the sum of the resultant products; we thus obtain a covariant which is called the first evectant of the original invariant. The second evectant is obtained by similarly operating upon all the symbols remaining which only occur in determinant factors, and so on for the higher evectants.

Ex. gr. From $(ac)^2(bd)^2(ad)(bc)$ we obtain

$$(bd)^2(bc)c_x^2d_x + (ac)^2(ad)c_xd_x^2$$
$$-(bd)^2(ad)a_x^2b_x - (ac)^2(bc)a_xb_x^2$$
$$= 4(bd)^2(bc)c_x^2d_x \text{ the first evectant;}$$

and thence $4c_x^2d_x^2$ the second evectant; in fact the two evectants are, to numerical factors *près*, the cubic covariant Q, and the square of the original cubic.

If θ be the degree of an invariant j

$$\theta j = \bar a_0 \frac{\partial j}{\partial a_0} + \bar a_1 \frac{\partial j}{\partial a_1} + \dots + \bar a_n \frac{\partial j}{\partial a_n}$$
$$= a_1^n \frac{\partial j}{\partial a_0} + a_1^{n-1} a_2 \frac{\partial j}{\partial a_1} + \dots + a_2^n \frac{\partial j}{\partial a_n}$$

and, herein transforming from a to x, we obtain the first evectant

$$p_x^n = \sum_k (-)^k x_1^k x_2^{n-k} \frac{\partial j}{\partial a_k}.$$

Combinants.—An important class of invariants, of several binary forms of the same order, was discovered by Sylvester. The invariants in question are invariants *quâ* linear transformation of the forms themselves as well as *quâ* linear transformation of the variables. If the forms be a_x^p, b_x^p, c_x^p, ... the Aronhold process, given by the operation δ as between any two of the forms, causes such an invariant to vanish. Thus it has annihilators of the forms

$$\bar{a}_0\frac{d}{d\bar{b}_0}+\bar{a}_1\frac{d}{d\bar{b}_1}+\bar{a}_2\frac{d}{d\bar{b}_2}+\dots$$
$$\bar{b}_0\frac{d}{da_0}+\bar{b}_1\frac{d}{da_1}+\bar{b}_2\frac{d}{da_2}+\dots$$

and Gordan, in fact, takes the satisfaction of these conditions as defining those invariants which Sylvester termed "Combinants." The existence of such forms seems to have been brought to Sylvester's notice by observation of the fact that the resultant of a_x^p and b_x^p must be a factor of the resultant of $\lambda a_x^p+\mu b_x^p$ and $\lambda' a_x^p+\mu' b_x^p$ for a common factor of the first pair must be also a common factor of the second pair; so that the condition for the existence of such common factor must be the same in the two cases. A leading proposition states that, if an invariant of λa_p^x and μb_x^p be considered as a form in the variables λ and μ, and an invariant of the latter be taken, the result will be a combinant of a_x^p and b_x^p. The idea can be generalized so as to have regard to ternary and higher forms each of the same order and of the same number of variables.

For further information see GORDAN. *Vorlesungen über Invariantentheorie*, B. ii. § 6, Leipzig, 1887; E. B. ELLIOTT. *Algebra of Quantics*, Art. 264, Oxford, 1895.

Associated Forms.—A system of forms, such that every form appertaining to the binary form is expressible as a rational and integral function of the members of the system, is difficult to obtain. If, however, we specify that all forms are to be rational, but not necessarily integral functions, a new system of forms arises which is easily obtainable. A binary form of order n contains n independent constants, three of which by linear transformation can be given determinate values; the remaining $n-3$ coefficients, together with the determinant of transformation, give us $n-2$ parameters, and in consequence one relation must exist between any $n-1$ invariants of the form, and fixing upon $n-2$ invariants every other invariant is a rational function of its members. Similarly regarding x_1, x_2 as additional parameters, we see that every covariant is expressible as a rational function of n fixed covariants. We can so determine these n covariants that every other covariant is expressed in terms of them by a fraction whose denominator is a power of the binary form.

First observe that with $f_x=a_x^n=b_x^n=\dots, f_1=a_1a_x^{n-1}, f_2=a_2a_x^{n-1}$, $f_x=f_1x_1+f_2x_2$, we find

$$(ab)=\frac{(af)b_x-(bf)a_x}{f_x};$$

and that thence every symbolic product is equal to a rational function of covariants in the form of a fraction whose denominator is a power of f_x. Making the substitution in any symbolic product the only determinant factors that present themselves in the numerator are of the form (af), (bf), (cf), ... and every symbol a finally appears in the form

$$\psi_k=(af)^ka_x^{n-k}.$$

ψ_k has f as a factor, and may be written $f.u_k$; for, observing that $\psi_0=f.=f.u_0$; $\psi_1=0=f.u_1$; where $u_0=1, u_1=0$,

assume that $\quad \psi_k=(af)^ka_x^{n-k}=f.u_k=a_x^n.u_x^{k(n-2)}.$

Taking the first polar with regard to y

$$(n-k)(af)^ka_x^{n-k-1}a_y+k(af)^{k-1}a_x^{n-k}(ab)(n-1)b_x^{n-2}b_y$$
$$=k(n-2)a_x^nu_x^{kn-2k-1}u_y+na_x^{n-1}a_yu_x^{k(n-2)},$$

and, writing f_2 and $-f_1$ for y_1 and y_2,

$$(n-k)(af)^{k+1}a_x^{n-k-1}+k(n-1)(ab)(af)^{k-1}(bf)a_x^{n-k}b_x^{n-2}$$
$$=k(n-2)f.(uf)u_x^{kn-2k-1}.$$

Moreover the second term on the left contains

$$(af)^{k-2}b_x^{k-2}=\frac{1}{2}\left\{(af)^{k-2}b_x^{k-2}-(bf)^{k-2}a_x^{k-2}\right\},$$

if k be uneven, and

$$(af)^{k-1}b_x^{k-1}=\frac{1}{2}\left\{(af)^{k-1}b_x^{k-1}-(bf)^{k-1}a_x^{k-1}\right\},$$

if k be even; in either case the factor

$$(af)b_x-(bf)a_x=(ab)f,$$

and therefore

$$(n-k)\psi_{k+1}+M.f=k(n-2)f.(uf)u_x^{kn-2k-1};$$

and ψ_{k+1} is seen to be of the form $f.u_{k+1}$.

We may write therefore

$$u_k=\frac{(af)^ka_x^{n-k}}{f}$$

These forms, n in number, are called "associated forms" of f ("Schwesterformen" "formes associées").

Every covariant is rationally expressible by means of the forms f, u_2, u_3, ... u_n since, as we have seen, $u_0=1$, $u_1=0$. It is easy to find the relations

$$u_2=\frac{1}{2}(f,f')^2,$$
$$u_3=((f,f')^2,f')$$
$$u_4=\frac{1}{2}(f,f')^4.f^2-\frac{3}{4}\{(f,f')^2\}^2,$$

and so on.

To exhibit any covariant as a function of u_0, u_1, u_2 ... take $a_y^n=(a_1y_1+a_2y_2)^n$ and transform it by the substitution

$$f_1y_1+f_2y_2=\xi \text{ where } f_1=a_1a_x^{n-1}, f_2=a_2a_x^{n-1},$$
$$x_2y_1-x_1y_2=\eta \qquad f=f_1x_1+f_2x_2;$$

thence

$$f.y_1=x_1\xi+f_2\eta;\ f.y_2=x_2\xi-f_1\eta,$$
$$f.a_y=a_x\xi+(af)\eta,$$

and

$$f^{n-1}.a_y^n=u_0\xi^n+\binom{n}{2}u_2\xi^{n-2}\eta^2+\binom{n}{3}u_3\xi^{n-3}\eta^3+\dots+u_n\eta^n.$$

Now a covariant of $a_x^n=f$ is obtained from the similar covariant of a_y^n by writing therein x_1, x_2, for y_1, y_2 and, since y_1, y_2 have been linearly transformed to ξ and η, it is merely necessary to form the covariants in respect of the form $(u_1\xi+u_2\eta)^n$, and then division, by the proper power of f, gives the covariant in question as a function of $f, u_0=1, u_2, u_3, \dots u_n$.

Ex. gr., in the case of the binary quartic,

$$f^3.a_y^4=\xi^4+3\Delta\xi^2\eta^2+4t\xi\eta^3+\left(\frac{1}{2}if^2-\frac{3}{4}\Delta^2\right)\eta^4$$

$$\text{and } j=6\begin{vmatrix}\bar{a}_0, \bar{a}_1, \bar{a}_2\\ \bar{a}_1, \bar{a}_2, \bar{a}_3\\ \bar{a}_2, \bar{a}_3, \bar{a}_4\end{vmatrix}=\frac{3}{f^3}\left(\frac{1}{2}i\Delta f^2-\Delta^3-2t^2\right);$$

which is exactly the relation connecting the five ground forms. The above system $f, u_2, u_3, \dots u_n$ is not, however, for many purposes the most convenient system of associated forms. Writing $(f,f')^{2k}=G_{2k}$, $((f,f')^{2k},f'')=H_{2k+1}$, Hermite and Clebsch have shown that u_s is expressible in terms of the s forms f, G_2, H_3, G_4, ... G_s or H_s according as s is even or uneven. Hence, we may take this for an associated system appertaining to a form of order s.

We have $\quad G_{2k}=(ab)^{2k}a_x^{n-2k}b_x^{n-2k},$

$$H_{2k+1}=(ab)^{2k}(ac)a_x^{n-2k-1}b_x^{n-2k}c_x^{n-1};$$
$$\text{but } f.(ab)=(af)b_x-(bf)a_x;\ (ac)c_x^{n-1}=(af);$$
$$\therefore\ G_{2k}.f^{2k}=a_x^{n-2k}b_x^{n-2k}\left\{(af)b_x-(bf)a_x\right\}^{2k},$$
$$H_{2k+1}.f^{2k}=a_x^{n-2k-1}b_x^{n-2k}(af)\left\{(af)b_x-(bf)a_x\right\}^{2k}.$$

Whence expression, by the binomial theorem, gives

$$G_{2k}f^{2k}=u_{2k}f^2-\binom{2k}{1}u_{2k-1}u_1.f^2+\binom{2k}{2}u_{2k-2}u_2f^2-\dots+u_{2k}f^2,$$

or,

$$G_{2k}.f^{2k-2}=2\left\{u_{2k}u_0+\binom{2k}{2}u_{2k-2}u_2-\binom{2k}{3}u_{2k-3}u_3\right.$$
$$\left.+\dots\frac{1}{2}(-)^k\binom{2k}{k}u_k^2\right\};$$

and, similarly,

$$H_{2k+1}.f^{2k-2}=u_{2k+1}u_0+\frac{2k(2k-3)}{2!}u_{2k-1}u_2-\dots(-)^k\binom{2k}{k}u_{k+1}u_k;$$

and, from these, we can express the members of the u system in terms of the G and H system.

As the symbolic expression of *forms with two series of cogredient variables*, we take

$$a_x^m\alpha_y^n=(a_1x_1+a_2x_2)^m(\alpha_1y_1+\alpha_2y_2)^n,$$
$$=\sum\binom{m}{k}\binom{n}{\lambda}a_1^{m-k}a_2^k\alpha_1^{n-\lambda}\alpha_2^\lambda x_1^{m-k}x_2^ky_1^{n-\lambda}y_2^\lambda,$$

the real expression being $\sum\binom{m}{k}\binom{n}{\lambda}\overline{a_k\alpha_\lambda}x_1^{m-k}x_2^ky_1^{n-\lambda}y_2^\lambda$; the form being of degree m in x_1, x_2 and of degree n in y_1, y_2, and the coefficients $\overline{a_k\alpha_\lambda}$ being arbitrary.

It may happen that $a_x^m\alpha_y^n$ is the product of the two forms a_x^m, α_y^n, and then $\overline{a_k\alpha_\lambda}=\bar{a}_k.\bar{\alpha}_\lambda$; this case is included in the general theory.

A symbolic product contains factors of seven types, viz. :—

$$\text{(i.) } a_x = b_x = \ldots, \qquad \text{(ii.) } \alpha_x = \beta_x = \ldots,$$
$$\text{(iii.) } a_y = b_y = \ldots, \qquad \text{(iv.) } \alpha_y = \beta_y = \ldots,$$
$$\text{(v.) } (ab), \qquad \text{(vi.) } (a\beta), \qquad \text{(vii) } (\alpha\beta),$$

and, if it is to have a real expression, each letter $a, b, c, \ldots$ must occur m times, and each letter $\alpha, \beta, \gamma, \ldots$ n times. An important proposition is the expression of $a_x^m \alpha_y^n$ in a series of polars of forms, of type $(a\alpha)^\lambda a_x^{m-\lambda} \alpha_x^{n-\lambda}$, each polar being multiplied by a power of (xy). Gordan's formula is

$$a_x^m \alpha_y^n = \sum \frac{\binom{m}{k}\binom{n}{k}}{\binom{m+n-k+1}{k}} \left\{ (a\alpha)^k a_x^{m-k} \alpha_x^{n-k} \right\}_y^{n-k} (xy)^k;$$

and the right-hand side is a simultaneous covariant of the forms $(a\alpha)^k a_x^{m-k} \alpha_x^{n-k}$ which involve but one series of variables.

Other useful series are

$$a_x^\lambda \alpha_y^n a_y^\mu = \sum \frac{\binom{\lambda}{k}\binom{n}{k}}{\binom{\lambda+\mu+n-k+1}{k}} \left\{ (a\alpha)^k a_x^{\lambda-k} \alpha_x^{n-k} \right\}_y^{n+\mu-k} (xy)^k;$$

$$\left(a_x^m \alpha_x^n\right)_y^n = \sum (-)^k \frac{\binom{m}{k}\binom{n}{k}}{\binom{m+n}{k}} (a\alpha)^k a_x^{m-k} \alpha_y^{n-k} (xy)^k.$$

As an application consider the second transvectant of the quartic a_x^4 with its Hessian, $(ab)^2 a_x^2 b_x^2 = \Delta_x^4$; Expand a member of the third polar of $(ab) a_x^3 b_x^3$, viz. :—

$$(ab) a_x^3 b_y = (ab) \left\{ a_x^3 b_x^3 \right\}_y^3 + \frac{3}{2} \left\{ (ab)^2 a_x^2 b_x^2 \right\}_y^2 (xy)$$
$$+ \frac{9}{10} (ab)^3 \left\{ a_x b_x \right\}_y^1 (xy)^2 + \frac{1}{4} (ab)^4 (xy)^3;$$

the first and third terms vanish, and hence

$$(ab) a_x^0 b_y^3 = \frac{3}{2} \left\{ \Delta_x^4 \right\}_y^2 (xy) + \frac{1}{4} (ab)^4 (xy)^3.$$

By a previous theorem if we transform from y to c and multiply by c_x, $\left\{ \Delta_x^4 \right\}_y^2 (xy)$ becomes $c_x^2 (\Delta c)^2 \Delta_x^2 = \left(\Delta_x^4, a_x^4 \right)^2$.

Hence

$$-(ab)(bc)^3 a_x^3 c_x = \frac{3}{2} \left(\Delta_x^4, a_x^4 \right)^2 + \frac{1}{4} (ab)^4 c_x^4,$$

and

$$-(ab)(bc)^3 a_x^3 c_x = \frac{1}{2} \left\{ (ac)(bc)^3 a_x^3 b_x - (ab)(bc)^3 a_x^3 c_x \right\}$$
$$= \frac{1}{2} (bc)^3 a_x \left\{ (ac) b_x - (ab) c_x \right\} = \frac{1}{2} (bc)^4 a_x^4 = \frac{1}{2} (ab)^4 c_x^4.$$
$$\therefore \left(\Delta_x^4, a_x^4 \right)^2 = \frac{1}{6} (ab)^4 c_x^4 = \frac{1}{6} i \cdot f.$$

Summary of Results.—We will now give a short account of the results to which the foregoing processes lead. Of any form a_x^n there exists a finite number of invariants and covariants, in terms of which all other covariants are rational and integral functions (cf. Gordan, Band ii. § 21). This finite number of forms is said to constitute the complete system. Of two or more binary forms there are also complete systems containing a finite number of forms. There are also algebraic systems, as above mentioned, involving fewer covariants which are such that all other covariants are rationally expressible in terms of them; but these smaller systems do not possess the same mathematical interest as those first mentioned.

The Binary Quadratic.—The complete system consists of the form itself, a_x^2, and the discriminant, which is the second transvectant of the form upon itself, viz.: $(f, f')^2 = (ab)^2$; or, in real coefficients, $2(\bar{a}_0 \bar{a}_2 - \bar{a}_1^2)$. The first transvectant, $(f, f')^1 = (ab) a_x b_x$, vanishes identically. Calling the discriminant D, the solution of the quadratic $a_x^2 = 0$ is given by the formula

$$a_x^2 = \frac{1}{\bar{a}_0} \left(\bar{a}_0 x_1 + \bar{a}_1 x_2 - x_2 \sqrt{-\frac{D}{2}} \right) \left(\bar{a}_0 x_1 + \bar{a}_1 x_2 + x_2 \sqrt{-\frac{D}{2}} \right).$$

If the form a_x^2 be written as the product of its linear factors $p_x q_x$, the discriminant takes the form $-\frac{1}{2}(pq)^2$. The vanishing of this invariant is the condition for equal roots. The simultaneous system of two quadratic forms a_x^2, α_x^2, say f and ϕ, consists of six forms, viz.: the two quadratic forms f, ϕ; the two discriminants $(f, f')^2, (\phi, \phi')^2$, and the first and second transvectants of f upon ϕ, $(f, \phi)^1$ and $(f, \phi)^2$, which may be written $(a\alpha) a_x \alpha_x$ and $(a\alpha)^2$. These fundamental or ground forms are connected by the relation

$$-2\{(f, \phi)^1\}^2 = f^2 (\phi, \phi')^2 - 2 f\phi (f, \phi)^2 + \phi^2 (f, f')^2.$$

If the covariant $(f, \phi)^1$ vanishes f and ϕ are clearly proportional and if the second transvectant of $(f, \phi)^1$ upon itself vanishes, f and ϕ possess a common linear factor; and the condition is both necessary and sufficient. In this case $(f, \phi)^1$ is a perfect square since its discriminant vanishes. If $(f, \phi)^1$ be not a perfect square, and r_x, s_x be its linear factors, it is possible to express f and ϕ in the canonical forms $\lambda_1 (r_x)^2 + \lambda_2 (s_x)^2$, $\mu_1 (r_x)^2 + \mu_2 (s_x)^2$ respectively. In fact, if f and ϕ have these forms, it is easy to verify that $(f, \phi)^1 = (\lambda\mu)(rs) r_x s_x$. The fundamental system connected with n quadratic forms consists of (i.) the n forms themselves $f_1, f_2, \ldots f_n$, (ii.) the $\binom{n}{2}$ functional determinants $\left(f_i, f_k\right)^1$, (iii.) the $\binom{n+1}{2}$ invariants $\left(f_i, f_k\right)^2$, (iv.) the $\binom{n}{3}$ forms $\left(f_i, \left(f_k, f_m\right)\right)^2$, each such form remaining unaltered for any permutations of i, k, m. Between these forms various relations exist (*cf.* Gordan, § 134).

The Binary Cubic.—The complete system consists of

$$f = a_x^3, \left(f, f'\right)^2 = (ab)^2 a_x b_x = \Delta_x^2, \left(f, \Delta\right) = (ab)^2 (ca) b_x c_x^2 = Q_x^3,$$

and

$$(\Delta, \Delta')^2 = (ab)^2 (cd)^2 (ad)(bc) = R.$$

To prove that this system is complete we have to consider

$$(f, \Delta)^2, (\Delta, \Delta')^1, (f, Q)^1, (f, Q)^2, (f, Q)^3, (\Delta, Q)^1, (\Delta, Q)^2,$$

and each of these can be shown either to be zero or to be a rational integral function f, Δ, Q and R. These forms are connected by the relation

$$2Q^2 + \Delta^3 + Rf^2 = 0.$$

The discriminant of f is equal to the discriminant of Δ, and is therefore $(\Delta, \Delta')^2 = R$; if it vanishes both f and Δ have two roots equal, Δ is a rational factor of f and Q is a perfect cube; the cube root being equal, to a numerical factor *près*, to the square root of Δ. The Hessian $\Delta = \Delta_x^2$ is such that $(f, \Delta)^2 = 0$, and if f is expressible in the form $\lambda(p_x)^3 + \mu(q_x)^3$, that is as the sum of two perfect cubes, we find that Δ_x^2 must be equal to $p_x q_x$ for then

$$\{\lambda(p_x)^3 + \mu(q_x)^3, p_x q_x\}^2 = 0.$$

Hence, if p_x, q_x be the linear factors of the Hessian Δ_x^2, the cubic can be put into the form $\lambda(p_x)^3 + \mu(q_x)^3$ and immediately solved. This method of solution fails when the discriminant R vanishes, for then the Hessian has equal roots, as also the cubic f. The Hessian in that case is a factor of f, and Q is the third power of the linear factor which occurs to the second power in f. If, moreover, Δ vanishes identically f is a perfect cube.

The Binary Quartic.—The fundamental system consists of five forms $a_x^4 = f$; $\left(f, f'\right)^2 = (ab)^2 a_x^2 b_x^2 = \Delta_x^4$; $\left(f, f'\right)^4 = (ab)^4 = i$; $\left(f, \Delta\right)^1 = (a\Delta) a_x^3 \Delta_x^3 = (ab)^2 (cb) a_x^3 b_x c_x^3 = t$; $\left(f, \Delta\right)^4 = (a\Delta)^4 = (ab)^2 (bc)^2 (ca)^2 = j$, viz., two invariants, two quartics, and a sextic. They are connected by the relation

$$2t^2 = \frac{1}{2} i f^2 \Delta - \Delta^3 - \frac{1}{3} j f^3.$$

The discriminant, whose vanishing is the condition that f may possess two equal roots, has the expression $j^2 - \frac{1}{6} i^3$; it is nine times the discriminant of the cubic resolvent $k^3 - \frac{1}{2} ik - \frac{1}{3} j$, and has also the expression $4(t, t')^6$. The quartic has four equal roots, that is to say, is a perfect fourth power, when the Hessian vanishes identically; and conversely. This can be verified by equating to zero the five coefficients of the Hessian $(ab)^2 a_x^2 b_x^2$. Gordan has also shown that the vanishing of the Hessian of the binary n^{ic} is the necessary and sufficient condition to ensure the form being a perfect n^{th} power. The vanishing of the invariants i and j is the necessary and sufficient condition to ensure the quartic having three equal roots. On the one hand, assuming the quartic to have the form $4x_1^3 x_2$, we find $i = j = 0$, and on the other hand, assuming $i = j = 0$, we find that the quartic must have the form $a_0 x_1^4 + 4a_1 x_1^3 x_2$ which proves the proposition. The quartic will have two pairs of equal roots, that is, will be a perfect square, if it and its Hessian merely differ by a numerical factor. For it is easy to establish the formula $(yx)^2 \Delta_x^4 = 2f \cdot f_y^2 - 2\left(f_y^1\right)^2$ connecting the Hessian with the quartic and its first and second polars; now α, a root of f, is also a root of Δ_x^4, and consequently the first polar $f_y^1 = y_1 \frac{\partial f}{\partial x_1} + y_2 \frac{\partial f}{\partial x_2}$ must also vanish for the root α, and thence $\frac{\partial f}{\partial x_1}$ and $\frac{\partial f}{\partial x_2}$ must also vanish for the same root; which proves that α is a double root of f, and f therefore a perfect square. When $f = 6x_1^2 x_2^2$ it will be found that $\Delta = -f$. The simplest form to which the quartic is in general reducible is $f=x_1^4+6mx_1^2x_2^2+x_2^4$, involving one parameter m; then $\Delta_2^4=2m(x_1^4+x_2^4)+2(1-3m^2)x_1^2x_2^2$; $i=2(1+3m^2)$; $j=6m(1-m)^2$; $t=(1-9m^2)(x_1^2-x_2^2)(x_1^2+x_2^2)x_1x_2$. The sextic covariant t is seen to be factorizable into three quadratic factors $\phi=x_1x_2$, $\psi=x_1^2+x_2^2$, $\psi=x_1^2-x_2^2$, which are such that the three mutual second transvectants vanish identically; they are for this reason termed conjugate quadratic factors. It is on a consideration of these factors of t that Cayley bases his solution of the quartic equation. For, since $-2t^2=\Delta^3-\frac{1}{2}if^2\Delta-\frac{1}{3}j(-f)^3$, he compares the right-hand side with the cubic resolvent $k^3-\frac{1}{2}i\lambda^2k-\frac{1}{3}j\lambda^3$, of $f=0$, and notices that they become identical on substituting Δ for k, and $-f$ for λ; hence, if k_1, k_2, k_3 be the roots of the resolvent,

$$-2t^2=(\Delta+k_1f)(\Delta+k_2f)(\Delta+k_3f);$$

and now, if all the roots of f be different, so also are those of the resolvent, since the latter, and f, have practically the same discriminant; consequently each of the three factors, of $-2t^2$, must be perfect squares and taking the square root

$$t=\frac{1}{\sqrt{-2}}\phi\cdot\chi\cdot\psi;$$

and it can be shown that ϕ, χ, ψ are the three conjugate quadratic factors of t above mentioned. We have $\Delta+k_1f=\phi^2$, $\Delta+k_2f=\chi^2$, $\Delta+k_3f=\psi^2$, and Cayley shows that a root of the quartic can be expressed in the determinant form

$$\begin{vmatrix}1, k_1, \phi_y^{\frac{1}{2}}\\ 1, k_2, \chi_y^{\frac{1}{2}}\\ 1, k_3, \psi_y^{\frac{1}{2}}\end{vmatrix}\begin{matrix}y_1=0\\ y_2=1\end{matrix}$$

the remaining roots being obtained by varying the signs which occur in the radicals $\phi_y^{\frac{1}{2}}, \chi_y^{\frac{1}{2}}, \psi_y^{\frac{1}{2}}$. The transformation to the normal form reduces the quartic to a quadratic. The new variables are the linear factors of ϕ. If $\phi=r_x\cdot s_x$, the normal form of a_x^4, can be shown to be given by

$$(rs)^4\cdot a_x^4=(ar)^4s_x^4+6(ar)^2(as)^2r_x^2s_x^2+(as)^4r_x^4;$$

ϕ is any one of the conjugate quadratic factors of t, so that, in determining r_x, s_x from $\sqrt{\Delta+k_1f}=0$, k_1 is any root of the resolvent. The transformation to the normal form, by the solution of a cubic and a quadratic, therefore, supplies a solution of the quartic. If $(\lambda\mu)$ is the modulus of the transformation by which a_x^4 is reduced to the normal form, i becomes $(\lambda\mu)^4i$, and j, $(\lambda\mu)^6j$; hence $\frac{i^3}{j^2}$ is absolutely unaltered by transformation, and is termed the absolute invariant. Since therefore $\frac{i^3}{j^2}=\frac{2}{9}\frac{(1+3m^2)^3}{m^2(1-m^2)^2}$ we have a cubic equation for determining m^2 as a function of the absolute invariant.

Remark.—Hermite has shown (*Crelle*, Bd. lii.) that the substitution, $z=\frac{i}{j}\cdot\frac{\Delta}{f}$, reduces $\frac{x_2\partial x_1-x_1\partial x_2}{\sqrt{f}}$ to the form

$$\frac{1}{2i}\sqrt{-\frac{j}{2}}\,\frac{\partial z}{\sqrt{\frac{1}{3}-\frac{1}{2}z+\frac{j^2}{i^3}z^3}}.$$

The Binary Quintic.—The complete system consists of 23 forms, of which the simplest are $f=a_x^5$; the Hessian $\mathrm{H}=(f,f')^2=(ab)^2a_x^3b_x^3$; the quadratic covariant $i=(f,f')^4=(ab)^4a_xb_x$; and the nonic covariant $\mathrm{T}=(f,(f',f'')^2)^1=(f,\mathrm{H})^1=(a\mathrm{H})a_x^4\mathrm{H}_x^5=(ab)^2(ca)a_x^3b_x^3c_x^4$; the remaining 19 are expressible as transvectants of compounds of these four.

There are four invariants $(i,i')^2$; $(i^3,\mathrm{H})^6$; $(f^2,i^5)^{10}$; $(f\mathrm{T},i^7)^{14}$
four linear forms $(f,i^2)^4$; $(f,i^3)^5$; $(i^4,\mathrm{T})^8$; $(i^5,\mathrm{T})^9$
three quadratic forms i; $(\mathrm{H},i^2)^4$; $(\mathrm{H},i^3)^5$
three cubic forms $(f,i)^2$; $(f,i^2)^3$; $(i^3,\mathrm{T})^6$
two quartic forms $(\mathrm{H},i)^2$; $(\mathrm{H},i^2)^3$.
three quintic forms f; $(f,i)^1$; $(i^2,\mathrm{T})^4$
two sextic forms H; $(\mathrm{H},i)^1$
one septic form $(i,\mathrm{T})^2$
one nonic form T.

We will write the cubic covariant $(f,i)^2=j$, and then remark that the result, $(f,j)^3=0$, can be readily established. The form j is completely defined by the relation $(f,j)^3=0$ as no other covariant possesses this property.

Certain covariants of the quintic involve the same determinant factors as appeared in the system of the quartic: these are f, H, i, T, and j, and are of special importance. Further, it is convenient to have before us two other quadratic covariants, viz., $\tau=(j,j')^2j_xj'_x$; $\theta=(i\tau)i_x\tau_x$; four other linear covariants, viz., $\alpha=-(ji)^2j_x$; $\beta=(i\alpha)i_x$; $\gamma=(\tau\alpha)\tau_x$; $\delta=(\tau\beta)\tau_x$. Further, in the case of invariants, we write $\mathrm{A}=(i,i')^2$ and take three new forms $\mathrm{B}=(i,\tau)^2$; $\mathrm{C}=(\tau,\tau')^2$; $\mathrm{R}=(\beta\gamma)$. Hermite expresses the quintic in a *forme-type* in which the constants are invariants and the variables linear covariants. If α,β be the linear forms, above defined, he raises the identity $a_x(\alpha\beta)=\alpha_x(a\beta)-\beta_x(a\alpha)$ to the fifth power (and in general to the power n) obtaining

$$(\alpha\beta)^5f=(a\beta)^5\alpha_x^5-5(a\beta)^4(a\alpha)\alpha_x^4\beta_x+\ldots-(a\alpha)^5\beta_x^5;$$

and then expresses the coefficients, on the right, in terms of the fundamental invariants. On this principle the covariant j is expressible in the form

$$\mathrm{R}^3j=\delta^3+\frac{3}{2}\mathrm{B}\delta^2\alpha+\frac{3}{4}\mathrm{AC}\delta\alpha^2+\frac{3}{8}\mathrm{C}(3\mathrm{AB}-4\mathrm{C})\alpha^3$$

when δ, α are the above defined linear forms.

Hence, solving the cubic,

$$\mathrm{R}^3j=(\delta-m_1\alpha)(\delta-m_2\alpha)(\delta-m_3\alpha)$$

wherein m_1, m_2, m_3 are invariants.

Sylvester showed that the quintic might, in general, be expressed as the sum of three fifth powers, viz., in the canonical form $f=k_1(p_x)^5+k_2(q_x)^5+k_3(r_x)^5$. Now, evidently, the third transvectant of f, expressed in this form, with the cubic $p_xq_xr_x$ is zero, and hence from a property of the covariant j we must have $j=p_xq_xr_x$; showing that the linear forms involved are the linear factors of j. We may therefore write

$$f=k_1(\delta-m_1\alpha)^5+k_2(\delta-m_2\alpha)^5+k_3(\delta-m_3\alpha)^5;$$

and we have merely to determine the constants k_1, k_2, k_3. To determine them notice that $\mathrm{R}=(\alpha\delta)$ and then

$$(f,\alpha^5)^5\ =-\mathrm{R}^5(k_1+k_2+k_3),$$
$$(f,\alpha^4\delta)^5=-5\mathrm{R}^5(m_1k_1+m_2k_2+m_3k_3),$$
$$(f,\alpha^3\delta^2)^5=-10\mathrm{R}^5(m_1^2k_1+m_2^2k_2+m_3^2k_3),$$

three equations for determining k_1, k_2, k_3. This canonical form depends upon j having three unequal linear factors. When C vanishes j has the form $j=p_x^2q_x$, and $(f,j)^3=(ap)^2(aq)a_x^2=0$. Hence, from the identity $a_x(pq)=p_x(aq)-q_x(ap)$, we obtain $(pq)^5f=(aq)^5p_x^5-5(ap)(aq)^4p_x^4q_x-(ap)^5q_x^5$, the required canonical form. Now, when $\mathrm{C}=0$, clearly (see *ante*) $\mathrm{R}^2j=\delta^2\rho$ where $\rho=\delta+\frac{3}{2}\mathrm{B}\alpha$; and Gordan then proves the relation

$$6\mathrm{R}^4.f=\mathrm{B}\delta^5+5\mathrm{B}\delta^4\rho-4\mathrm{A}^2\rho^5,$$

which is Bring's form of quintic at which we can always arrive, by linear transformation, whenever the invariant C vanishes.

Remark.—The invariant C is a numerical multiple of the resultant of the covariants i and j, and if $\mathrm{C}=0$, ρ is the common factor of i and j.

The discriminant is the resultant of $\frac{\partial f}{\partial x_1}$ and $\frac{\partial f}{\partial x_2}$ and of degree 8 in the coefficients; since it is a rational and integral function of the fundamental invariants it is expressible as a linear function of A^2 and B; it is independent of C, and is therefore unaltered when C vanishes; we may therefore take f in the canonical form

$$6\mathrm{R}^4f=\mathrm{B}\delta^5+5\mathrm{B}\delta^4\rho-4\mathrm{A}^2\rho^5.$$

The two equations

$$\frac{\partial f}{\partial\delta}=5(\mathrm{B}\delta^4+4\mathrm{B}\delta^3\rho)=0,$$
$$\frac{\partial f}{\partial\rho}=5(\mathrm{B}\delta^4-4\mathrm{A}^2\rho^4)=0,$$

yield by elimination of δ and ρ the discriminant

$$\mathrm{D}=64\mathrm{B}-\mathrm{A}^2.$$

The general equation of degree 5 cannot be solved algebraically, but the roots can be expressed by means of elliptic modular functions. For an algebraic solution the invariants must fulfil certain conditions. When $\mathrm{R}=0$, and neither of the expressions $\mathrm{AC}-\mathrm{B}^2$, $2\mathrm{AB}-3\mathrm{C}$ vanishes, the covariant α_x is a linear factor of f; but, when $\mathrm{R}=\mathrm{AC}-\mathrm{B}^2=2\mathrm{AB}-3\mathrm{C}=0$, α_x also vanishes, and then f is the product of the form j_x^2 and of the Hessian of j_x^3. When α_x and the invariants B and C all vanish, either A or j must vanish; in the former case j is a perfect cube, its Hessian vanishing, and further f contains j as a factor; in the latter case, if ρ_x, σ_x be the linear factors of i, f can be expressed as $(\rho\sigma)^5f=c_1\rho_x^5+c_2\sigma_x^5$; if both A and j vanish i also vanishes identically, and so also does f. If, however, the condition be the vanishing of i, f contains a linear factor to the fourth power.

The Binary Sextic.—The complete system consists of 26 forms, of which the simplest are $f=a_x^6$; the Hessian $\mathrm{H}=(ab)^2a_x^4b_x^4$; the quartic $i=(ab)^4a_x^2b_x^2$; the covariants $l=(ai)^4a_x^2$; $\mathrm{T}=(ab)^2(cb)a_x^4b_x^3c_x^5$; and the invariants $\mathrm{A}=(ab)^6$; $\mathrm{B}=(ii')^4$. There are

5 invariants : $(a,b)^6, (i,i')^4, (l,l')^2, (f,l^3)^6, ((f,i),l^4)^8$;
6 of order 2 : $l, (i,l)^2, (f,l^2)^4, (i,l^2)^3, (f,l^3)^5, ((f,i),l^3)^6$;
5 of order 4 : $i, (f,l)^2, (i,l), (f,l^2)^3, ((f,i),l^2)^4$;
5 of order 6 : $f, p=(ai)^2a_x^4i_x^2, (f,l), ((f,i),l)^2, (p,l)$;
3 of order 8 : $\mathrm{H}, (f,i), (\mathrm{H},l)$;
1 of order 10 : (H,i);
1 of order 12 : T.

For a further discussion of the binary sextic see Gordan *loc. cit.*, Clebsch *loc. cit.* The complete systems of the quintic and sextic were first obtained by Gordan in 1868 (*Journ. f. Math.* lxix. 323-354). Von Gall in 1880 obtained the complete system of the binary octavic (*Math. Ann.* xvii. 31-52, 139-152, 456); and, in 1888, that of the binary septimic, which proved to be much more complicated (*Math. Ann.* xxxi. 318-336). Single binary forms of higher and finite order have not been studied with complete success, but the system of the binary form of infinite order has been completely determined by Sylvester, Cayley, MacMahon, and Stroh, each of whom contributed to the theory.

As regards simultaneous binary forms, the system of two quadratics, and of any number of quadratics, is alluded to above, and has long been known. The system of the quadratic and cubic, consisting of 15 forms, and that of two cubics, consisting of 26 forms, were obtained by Salmon and Clebsch; that of the cubic and quartic we owe to Gundelfinger (*Programm Stuttgart*, 1869, 1-43); that of the quadratic and quintic to Winter (*Programm Darmstadt*, 1880); that of the quadratic and sextic to von Gall (*Programm Lemgo*, 1873); that of two quartics to Gordan (*Math. Ann.* ii. 227-281, 1870); and to Bertini (*Batt. Giorn.* xiv. 1-14, 1876; also *Math. Ann.*, xi. 30-41, 1877). The system of four forms, of which two are linear and two quadratic, has been investigated by Perrin (*S. M. F. Bull.* xv. 45-61, 1887).

Ternary and Higher Forms.—The ternary form of order n is represented symbolically by

$$(a_1x_1+a_2x_2+a_3x_3)^n=a_x^n;$$

and, as usual, $b, c, d, \ldots$ are alternative symbols, so that

$$a_x^n=b_x^n=c_x^n=d_x^n=\ldots.$$

To form an invariant or covariant we have merely to form a product of factors of two kinds, viz. determinant factors (abc), (abd), (bce), etc...., and other factors $a_x, b_x, c_x, \ldots$ in such manner, that each of the symbols $a, b, c, \ldots$ occurs n times. Such a symbolic product, if it does not vanish identically, denotes an invariant or a covariant, according as factors $a_x, b_x, c_x, \ldots$ do not or do appear. To obtain the real form we multiply out, and, in the result, substitute for the products of symbols the real coefficients which they denote.

For example, take the ternary quadratic

$$(a_1x_1+a_2x_2+a_3x_3)^2=a_x^2,$$

or in real form $ax_1^2+bx_2^2+cx_3^2+2fx_2x_3+2gx_3x_1+2hx_1x_2$. We can see that $(abc)\,a_xb_xc_x$ is not a covariant, because it vanishes identically, the interchange of a and b changing its sign instead of leaving it unchanged; but $(abc)^2$ is an invariant. If a_x^2, b_x^2, c_x^2 be different forms we obtain, after development of the squared determinant and conversion to the real form (employing single and double dashes to distinguish the real coefficients of b_x^2 and c_x^2),

$$\begin{aligned}&a(b'c''+b''c'-2f'f'')+b(c'a''+c''a'-2g'g'')\\&+c(a'b''+a''b'-2h'h'')+2f(g'h''+g''h'-a'f''-a''f')\\&+2g(h'f''+h''f'-b'g''-b''g')+2h(f'g''+f''g'-c'h''-c''h');\end{aligned}$$

a simultaneous invariant of the three forms, and now suppressing the dashes we obtain

$$6(abc+2fgh-af^2-bg^2-ch^2),$$

the expression in brackets being the well-known invariant of a_x^2, the vanishing of which expresses the condition that the form may break up into two linear factors, or, geometrically, that the conic may represent two right lines. The complete system consists of the form itself and this invariant.

The ternary cubic has been investigated by Cayley, Aronhold, Hermite, Brioschi, and Gordan. The principal reference is to Gordan (*Math. Ann.* i. 90-128, 1869, and vi. 436-512, 1873). The complete covariant and contravariant system includes no fewer than 34 forms; from its complexity it is desirable to consider the cubic in a simple canonical form; that chosen by Cayley was $ax^3+by^3+cz^3+6dxyz$ (*Amer. J. Math.* iv. 1-16, 1881). Another form, associated with the theory of elliptic functions, has been considered by Dingeldey (*Math. Ann.* xxxi. 157-176, 1888), viz. $xy^2-4z^3+g_2zx^2y+g_3x^3$, and also the special form axz^2-4by^3 of the cuspidal cubic. An investigation, by non-symbolic methods, is due to Mertens (*Wien. Ber.* xcv. 942-991, 1887). Hesse showed independently that the general ternary cubic can be reduced, by linear transformation, to the form

$$x^3+y^3+z^3+6mxyz,$$

a form which involves 9 independent constants, as should be the case; it must, however, be remarked that the counting of constants is not a sure guide to the existence of a conjectured canonical form. Thus the ternary quartic is not, in general, expressible as a sum of five 4th powers as the counting of constants might have led one to expect, a theorem due to Sylvester. Hesse's canonical form shows at once that there cannot be more than two independent invariants; for if there were three we could, by elimination of the modulus of transformation, obtain two functions of the coefficients equal to functions of m, and thus, by elimination of m, obtain a relation between the coefficients, showing them not to be independent, which is contrary to the hypothesis.

The simplest invariant is $\mathrm{S}\equiv(abc)(abd)(acd)(bcd)$ of degree 4, which for the canonical form of Hesse is $m(1-m^3)$; its vanishing indicates that the form is expressible as a sum of three cubes. The Hessian is symbolically $(abc)^2a_xb_xc_x=\mathrm{H}_x^3$, and for the canonical form $(1+2m^3)xyz-m^2(x^3+y^3+z^3)$. By the process of Aronhold we can form the invariant S for the cubic $a_x^3+\lambda\mathrm{H}_x^3$, and then the coefficient of λ is the second invariant T. Its symbolic expression, to a numerical factor *pres*, is

$$(\mathrm{H}bc)(\mathrm{H}bd)(\mathrm{H}cd)(bcd),$$

and it is clearly of degree 6.

One more covariant is requisite to make an *algebraically* complete set. This is of degree 8 in the coefficients, and degree 6 in the variables, and, for the canonical form, has the expression

$$\begin{aligned}&-9m^6(x^3+y^3+z^3)^2-(2m+5m^4+20m^7)(x^3+y^3+z^3)xyz\\&-(15m^2+78m^5-12m^8)x^2y^2z^2+(1+8m^3)^2(y^3z^3+z^3x^3+x^3y^3).\end{aligned}$$

Passing on to the ternary quartic we find that the number of ground forms is apparently very great. Gordan (*Math. Ann.* xvii. 217-233), limiting himself to a particular case of the form, has determined 54 ground forms, and Maisano (*Batt. G.* xix. 198-237, 1881) has determined all up to and including the 5th degree in the coefficients.

The system of two ternary quadratics consists of 20 forms; it has been investigated by Gordan (*Clebsch-Lindemann's Vorlesungen*, i. 288, also *Math. Ann.* xix. 529-552); Perrin (*S. M. F. Bull.* xviii. 1-80, 1890); Rosanes (*Math. Ann.* vi. 264); and Gerbaldi (*Annali* (2), xvii. 161-196).

Ciamberlini has found a system of 127 forms appertaining to three ternary quadratics (*Batt. G.* xxiv. 141-157).

Forsyth has discussed the *algebraically* complete sets of ground forms of ternary and quaternary forms (see *Amer. J.* xii. 1-60, 115-160, and *Camb. Phil. Trans.* xiv. 409-466, 1889). He proves, by means of the six linear partial differential equations satisfied by the concomitants, that, if any concomitant be expanded in powers of x_1, x_2, x_3, the point variables—and of u_1, u_2, u_3, the contragredient line variables—it is completely determinate if its leading coefficient be known. For the unipartite ternary quantic of order n he finds that the fundamental system contains $\frac{1}{2}(n+4)(n-1)$ individuals. He successfully considers the systems of two and three simultaneous ternary quadratics. In Part III. of the Memoir he discusses bi-ternary quantics, and in particular those which are lineo-linear, quadrato-linear, cubo-linear, quadrato-quadratic, cubo-cubic, and the system of two lineo-linear quantics. He shows that the system of the bi-ternary $n^{ic}m^{ic}$ comprises

$$\frac{1}{4}(n+1)(n+2)(m+1)(m+2)-3 \text{ individuals.}$$

Bibliographical references to ternary forms are given by Forsyth (*Amer. J.* xii. p. 16), and by Cayley (*Amer. J.* iv. 1881).

IV. ENUMERATING GENERATING FUNCTIONS.

Professor Michael Roberts (*Quart. Math. J.* iv.) was the first to remark that the study of covariants may be reduced to the study of their leading coefficients, and that from any relations connecting the latter are immediately derivable the relations connecting the former. It has been shown above that a covariant, in general, satisfies four partial differential equations. Two of these show that the leading coefficient of any covariant is an isobaric and homogeneous function of the coefficients of the form; the remaining two may be regarded as operators which cause the vanishing of the covariant. These may be written, for the binary n^{ic},

$$\Sigma k a_{k-1}\frac{d}{da_k} - x_2\frac{d}{dx_1} = 0,$$

$$\Sigma(n-k)a_{k+1}\frac{d}{da_k} - x_1\frac{d}{dx_2} = 0;$$

or in the form

$$\Omega - x_2\frac{d}{dx_1} = 0,\ O - x_1\frac{d}{dx_2} = 0;$$

where

$$\Omega = a_0\frac{d}{da_1} + 2a_1\frac{d}{da_2} + \dots + na_{n-1}\frac{d}{da_n},$$

$$O = na_1\frac{d}{da_0} + (n-1)a_2\frac{d}{da_1} + \dots + a_n\frac{d}{da_{n-1}}.$$

Let a covariant of degree ϵ in the variables, and of degree θ in the coefficients (the weight of the leading coefficient being w and $n\theta - \epsilon w = 2$), be

$$C_0x_1^{\epsilon} + \epsilon c_1x_1^{\epsilon-1}x_2 + \dots.$$

Operating with $\Omega - x_2\frac{d}{dx_1}$ we find $\Omega C_0 = 0$; that is to say, C_0 satisfies *one* of the two partial differential equations satisfied by an invariant. It is for this reason called a seminvariant, and every seminvariant is the leading coefficient of a covariant. The whole theory of invariants of a binary form depends upon the solutions of the equation $\Omega = 0$. Before discussing these it is best to transform the binary form by substituting $1!a_1, 2!a_2, 3!a_3, \dots n!a_n$, for $a_1, a_2, a_3 \dots a_n$ respectively;
it then becomes

$$a_0x_1^n + na_1x_1^{n-1}x_2 + n(n-1)a_2x_1^{n-2}x_2^2 + \dots + n!a_nx_2^n,$$

and Ω takes the simpler form

$$a_0\frac{d}{da_1} + a_1\frac{d}{da_2} + a_2\frac{d}{da_3} + \dots + a_{n-1}\frac{d}{da_n}.$$

One advantage we have obtained is that, if we now write $a_0 = 0$, and substitute a_{s-1} for a_s when $s > 0$, we obtain

$$a_0\frac{d}{da_1} + a_1\frac{d}{da_2} + a_2\frac{d}{da_3} + \dots + a_{n-2}\frac{d}{da_{n-1}}$$

which is the form of Ω for a binary $n - 1^{ic}$.

Hence, by merely diminishing each suffix in a seminvariant by unity, we obtain another seminvariant of the same degree, and of weight $w - \theta$, appertaining to the $n - 1^{ic}$. Also, if we increase each suffix in a seminvariant, we obtain terms, free from a_0, of some seminvariant of degree θ and weight $w + \theta$. *Ex. gr.* from the invariant $a_2^2 - 2a_1a_3 + 2a_0a_4$ of the quartic the diminishing process yields $a_1^2 - 2a_0a_2$, the leading coefficient of the Hessian of the cubic, and the increasing process leads to $a_3^2 - 2a_2a_4 + 2a_1a_5$ which only requires the additional term $-2a_0a_6$ to become a seminvariant of the sextic. A more important advantage, springing from the new form of Ω, arises from the fact that if

$$x^n - a_1x^{n-1} + a_2x^{n-2} - \dots (-)^n a_n = (x - \alpha_1)(x - \alpha_2)\dots(x - \alpha_n),$$

the sums of powers $\Sigma\alpha^2, \Sigma\alpha^3, \Sigma\alpha^4, \dots \Sigma\alpha^n$ all satisfy the equation $\Omega = 0$. Hence, excluding a_0, we may, in partition notation, write down the fundamental solutions of the equation, viz.—

$$(2), (3), (4), \dots (n),$$

and say that, with a_0, we have an *algebraically* complete system. Every symmetric function denoted by partitions, not involving the figure unity (say a non-unitary symmetric function), which remains unchanged by any increase of n, is also a seminvariant, and we may take if we please another fundamental system, viz.—

$$a_0, (2), (3), (22), (32), \dots (2^{\frac{1}{2}n}) \text{ or } (32^{\frac{1}{2}(n-3)}).$$

Observe that, if we subject any symmetric function $(p_1p_2p_3\dots)$ to the diminishing process, it becomes $a_0^{p_1-p_2}(p_2p_3\dots)$.

Next consider the solutions of $\Omega = 0$ which are of degree θ and weight w. The general term in a solution involves the product $a_0^{\pi_0}a_1^{\pi_1}a_2^{\pi_2}\dots a_n^{\pi_n}$ wherein $\Sigma\pi = \theta$, $\Sigma s\pi_s = w$; the number of such products that may appear depends upon the number of partitions of w into θ or fewer parts limited not to exceed n in magnitude. Let this number be denoted by $(w; \theta, n)$. In order to obtain the seminvariants we would write down the $(w; \theta, n)$ terms each associated with a literal coefficient; if we now operate with Ω we obtain a linear function of $(w - 1; \theta, n)$ products, for the vanishing of which the literal coefficients must satisfy $(w - 1; \theta, n)$ linear equations; hence $(w; \theta, n) - (w - 1; \theta, n)$ of these coefficients may be assumed arbitrarily, and the number of linearly independent solutions of $\Omega = 0$, of the given degree and weight, is precisely $(w; \theta, n) - (w - 1; \theta, n)$. This theory is due to Cayley; its validity depends upon showing that the $(w - 1; \theta, n)$ linear equations satisfied by the literal coefficients are independent; this has only recently been established by E. B. Elliott. These seminvariants are said to form an asyzygetic system. It is shown in the Article on COMBINATORIAL ANALYSIS that $(w; \theta, n)$ is the coefficient of $a^\theta z^w$ in the ascending expansion of the fraction

$$\frac{1}{1-a.1-az.1-az^2.\dots 1-az^n}.$$

Hence $(w; \theta, n) - (w - 1; \theta, n)$ is given by the coefficient of $a^\theta z^w$ in the fraction

$$\frac{1-z}{1-a.1-az.1-az^2.\dots 1-az^n},$$

the enumerating generating function of asyzygetic seminvariants. We may, by a well-known theorem, write the result as a coefficient of z^w in the expansion of

$$\frac{1-z^{n+1}.1-z^{n+2}.\dots 1-z^{n+\theta}}{1-z^2.1-z^3.\dots 1-z^\theta};$$

and since this expression is unaltered by the interchange of n and θ we prove Hermite's Law of Reciprocity, which states that the asyzygetic forms of degree θ for the n^{ic} are equinumerous with those of degree n for the θ^{ic}.

The degree of the covariant in the variables is $\epsilon = n\theta - 2w$; consequently we are only concerned with positive terms in the developments and $(w, \theta, n) - (w - 1; \theta, n)$ will be negative unless $n\theta - 2w \geqslant 0$. It is convenient to enumerate the seminvariants of degree θ and order $\epsilon = n\theta - 2w$ by a generating function; so, in the first written generating function for seminvariants, write $\frac{1}{z^2}$ for z and az^n for a; we obtain

$$\frac{1-z^{-2}}{1-az^n.1-az^{n-2}.1-az^{n-4}.\dots 1-az^{-n+4}.1-az^{-n+2}.1-az^{-n}}$$

in which we have to take the coefficient of $a^\theta z^{n\theta-2w}$, the expansion being in ascending powers of a. As we have to do only with that part of the expansion which involves positive powers of z, we must try to isolate that portion, say $A_n(z)$. For $n = 2$ we can prove that the complete function may be written

$$A_2(z) - \frac{1}{z^2}A_2\left(\frac{1}{z}\right),$$

where

$$A_2(z) = \frac{1}{1-az^2.1-a^2};$$

and this is the reduced generating function which tells us, by its denominator factors, that the complete system of the quadratic is composed of the form itself of degree order 1, 2 shown by az^2, and of the Hessian of degree order 2, 0 shown by a^2.

Again, for the cubic, we can find

$$A_3(z) = \frac{1-a^6z^6}{1-az^3.1-a^2z^2.1-a^3z^3.1-a^4},$$

where the ground forms are indicated by the denominator factors, viz.: these are the cubic itself of degree order 1, 3; the Hessian of degree order 2, 2; the cubi-covariant G of degree order 3, 3, and the quartic invariant of degree order 4, 0. Further, the numerator factor establishes that these are not all algebraically independent, but are connected by a syzygy of degree order 6, 6.

Similarly for the quartic

$$A_4(z) = \frac{1-a^6z^{12}}{1-az^4.1-a^2.1-a^2z^4.1-a^3.1-a^3z^6},$$

establishing the 5 ground forms and the syzygy which connects them.

The process is not applicable with complete success to quintic and higher ordered binary forms. This arises from the circumstance that the simple syzygies between the ground forms are not all independent, but are connected by second syzygies, and these again by third syzygies, and so on; this introduces new difficulties which have not been completely overcome. As regards invariants a little further progress has been made by Cayley, who established the two generating functions for the quintic

$$\frac{1-a^{36}}{1-a^4.1-a^8.1-a^{12}.1-a^{18}},$$

and for the sextic

$$\frac{1-a^{30}}{1-a^2.1-a^4.1-a^6.1-a^{10}.1-a^{15}}.$$

Accounts of further attempts in this direction will be found in Cayley's *Memoirs on Quantics* (Collected Papers), in the papers of Sylvester and Franklin (*Amer. J.* i.-iv.), and in Elliott's *Algebra of Quantics*, chap. viii.

Perpetuants.—Many difficulties, connected with binary forms of finite order, disappear altogether when we come to consider the form of infinite order. In this case the ground forms, called also perpetuants, have been enumerated and actual representative seminvariant forms established. Putting n equal to ∞, in a generating function obtained above, we find that the function, which enumerates the asyzygetic seminvariants of degree θ, is

$$\frac{1}{1-z^2\cdot 1-z^3\cdot 1-z^4\ldots 1-z^\theta}$$

that is to say, of the weight w, we have one form corresponding to each non-unitary partition of w into the parts $2, 3, 4, \ldots \theta$. The extraordinary advantage of the transformation of Ω to association with non-unitary symmetric functions is now apparent; for we may take, as representative forms, the symmetric functions which are symbolically denoted by the partitions referred to. *Ex. gr.*, of degree 3 weight 8, we have the two forms (3^22), $a(2^4)$. If we wish merely to enumerate those whose partitions contain the figure θ, and do not therefore contain any power of a as a factor, we have the generator

$$\frac{z^\theta}{1-z^2\cdot 1-z^3\cdot 1-z^4\ldots 1-z^\theta}.$$

If $\theta=2$, every form is obviously a ground form or perpetuant, and the series of forms is denoted by (2), (2^2), (2^3), $\ldots(2^{\kappa+1})\ldots$. Similarly, if $\theta=3$, every form $(3^{\kappa+1}2^\lambda)$ is a perpetuant. For these two cases the perpetuants are enumerated by

$$\frac{z^2}{1-z^2}, \text{ and } \frac{z^3}{1-z^2\cdot 1-z^3}$$

respectively.

When $\theta=4$ it is clear that no form, whose partition contains a part 3, can be reduced; but every form, whose partition is composed of the parts 4 and 2, is by elementary algebra reducible by means of perpetuants of degree 2. These latter forms are enumerated by $\frac{z^4}{1-z^2\cdot 1-z^4}$; hence the generator of quartic perpetuants must be

$$\frac{z^4}{1-z^2\cdot 1-z^3\cdot 1-z^4}-\frac{z^4}{1-z^2\cdot 1-z^4}=\frac{z^7}{1-z^2\cdot 1-z^3\cdot 1-z^4};$$

and the general form of perpetuant is $(4^{\kappa+1}3^{\lambda+1}2^\mu)$.

When $\theta \geq 5$, the reducible forms are connected by syzygies which there is some difficulty in enumerating. Sylvester, Cayley, and MacMahon succeeded, by a laborious process, in establishing the generators for $\theta=5$, and $\theta=6$, viz.:

$$\frac{z^{15}}{1-z^2\cdot 1-z^3\cdot 1-z^4\cdot 1-z^5}, \quad \frac{z^{31}}{1-z^2\cdot 1-z^3\cdot 1-z^4\cdot 1-z^5\cdot 1-z^6};$$

but the true method of procedure is that of Stroh which we are about to explain.

Method of Stroh.—In the section on "Symmetric Functions," it was noted that Stroh considers

$$(\sigma_1\alpha_1+\sigma_2\alpha_2+\ldots+\sigma_\theta\alpha_\theta)^w,$$

where $\sigma_1+\sigma_2+\ldots+\sigma_\theta=0$ and $\frac{\alpha_1^s}{s!}=\frac{\alpha_2^s}{s!}=\ldots=\frac{\alpha_\theta^s}{s!}=a_s$, symbolically, to be the fundamental form of seminvariant of degree θ and weight w; he observes that every form of this degree and weight is a linear function of such symbolic expressions. We may write

$$(1+\sigma_1\xi)(1+\sigma_2\xi)\ldots(1+\sigma_\theta\xi)=1+A_2\xi^2+A_3\xi^3+\ldots+A_\theta\xi^\theta.$$

If we expand the symbolic expression by the multinomial theorem, and remember that any symbolic product $\alpha_1^{\pi_1}\alpha_2^{\pi_2}\alpha_3^{\pi_3}\ldots$ retains the same value, however the suffixes be permuted, we shall obtain a sum of terms, such as $w!\frac{\alpha_1^{\pi_1}}{\pi_1!}\frac{\alpha_2^{\pi_2}}{\pi_2!}\frac{\alpha_3^{\pi_3}}{\pi_3!}\ldots\Sigma\sigma_1^{\pi_1}\sigma_2^{\pi_2}\sigma_3^{\pi_3}\ldots$, which in real form is $w!\,a_{\pi_1}a_{\pi_2}a_{\pi_3}\ldots\Sigma\sigma_1^{\pi_1}\sigma_2^{\pi_2}\sigma_3^{\pi_3}\ldots$; and, if we express $\Sigma\sigma_1^{\pi_1}\sigma_2^{\pi_2}\sigma_3^{\pi_3}\ldots$ in terms of $A_2, A_3, \ldots$ and arrange the whole as a linear function of products of $A_2, A_3, \ldots$, each coefficient will be a seminvariant, and the aggregate of the coefficients will give us the complete asyzygetic system of the given degree and weight. When the proper degree θ is $< w$ a factor $a_0^{w-\theta}$ must be of course understood.

Ex. gr.

$$\frac{1}{2!}(\sigma_1\alpha_1+\sigma_2\alpha_2+\sigma_3\alpha_3+\sigma_4\alpha_4)^2=\frac{\alpha_1^2}{2!}\Sigma\sigma_1^2+\alpha_1\alpha_2\Sigma\sigma_1\sigma_2$$
$$=a_2(-2A_2)+a_1^2A_2=(a_1^2-2a_2)A_2=(2)A_2\equiv a_0^2(2)A_2.$$

In general the coefficient, of any product $A_{\pi_1}A_{\pi_2}A_{\pi_3}\ldots$, will have, as coefficient, a seminvariant which, when expressed by partitions, will have as leading partition (preceding in dictionary order all others) the partition $(\pi_1\pi_2\pi_3\ldots)$. Now the symbolic expression of the seminvariant can be expanded by the binomial theorem so as to be exhibited as a sum of products of seminvariants, of lower degrees, if $\sigma_1\alpha_1+\sigma_2\alpha_2+\ldots+\sigma_\theta\alpha_\theta$ can be broken up into any two portions

$$(\sigma_1\alpha_1+\sigma_2\alpha_2+\ldots+\sigma_s\alpha_s)+(\sigma_{s+1}\alpha_{s+1}+\sigma_{s+2}\alpha_{s+2}+\ldots+\sigma_\theta\alpha_\theta),$$

such that $\sigma_1+\sigma_2+\ldots+\sigma_s=0$, for then

$$\sigma_{s+1}+\sigma_{s+2}+\ldots+\sigma_\theta=0;$$

and each portion raised to any power denotes a seminvariant. Stroh assumes that every reducible seminvariant can in this way be reduced. The existence of such a relation, as $\sigma_1+\sigma_2+\ldots+\sigma_s=0$, necessitates the vanishing of a certain function of the coefficients $A_2, A_3, \ldots A_\theta$, and as a consequence *one* product of these coefficients can be eliminated from the expanded form and no seminvariant, which appears as a coefficient to such a product (which may be the whole or only a part of the complete product with which the seminvariant is associated), will be capable of reduction.

Ex. gr. for $\theta=2$, $(\sigma_1\alpha_1+\sigma_2\alpha_2)^w$; either σ_1 or σ_2 will vanish if $\sigma_1\sigma_2=A_2=0$; but every term, in the development, is of the form $(222\ldots)A_2^{\frac{1}{2}w}$ and therefore vanishes; so that none are left to undergo reduction. Therefore every form of degree 2, except of course that one whose weight is zero, is a perpetuant. The generating function is $\frac{z^2}{1-z^2}$.

For $\theta=3$, $(\sigma_1\alpha_1+\sigma_2\alpha_2+\sigma_3\alpha_3)^w$; the condition is clearly $\sigma_1\sigma_2\sigma_3=A_3=0$, and since every seminvariant, of proper degree 3, is associated, as coefficient, with a product containing A_3, all such are perpetuants. The general form is $(3^\kappa 2^\lambda)$ and the generating function $\frac{z^3}{1-z^2\cdot 1-z^3}$.

For $\theta=4$, $(\sigma_1\alpha_1+\sigma_2\alpha_2+\sigma_3\alpha_3+\sigma_4\alpha_4)^w$; the condition is

$$\sigma_1\sigma_2\sigma_3\sigma_4(\sigma_1+\sigma_2)(\sigma_1+\sigma_3)(\sigma_1+\sigma_4)=A_4A_3=0.$$

Hence every product of A_1, A_2, A_3, A_4, which contains the product A_4A_3 disappears *before* reduction; this means that every seminvariant, whose partition contains the parts 4, 3, is a perpetuant. The general form of perpetuant is $(4^\kappa 3^\lambda 2^\mu)$ and the generating function

$$\frac{z^7}{1-z^2\cdot 1-z^3\cdot 1-z^4}.$$

In general when θ is even and $=2\phi$, the condition is

$$\sigma_1\sigma_2\ldots\sigma_{2\phi}\Pi(\sigma_1+\sigma_2)\Pi(\sigma_1+\sigma_2+\sigma_3)\ldots\Pi(\sigma_1+\sigma_2+\ldots+\sigma_\phi)=0;$$

and we can determine the lowest weight of a perpetuant; the degree in the quantities σ is

$$2\phi+\binom{2\phi}{2}+\binom{2\phi}{3}+\ldots+\frac{1}{2}\binom{2\phi}{\phi}=2^{2\phi-1}-1=2^{\theta-1}-1.$$

Again, if θ is uneven $=2\phi+1$, the condition is

$$\sigma_1\sigma_2\ldots\sigma_{2\phi+1}\Pi(\sigma_1+\sigma_2)\Pi(\sigma_1+\sigma_2+\sigma_3)\ldots\Pi(\sigma_1+\sigma_2+\ldots+\sigma_\phi)=0;$$

and the degree, in the quantities σ, is

$$2\phi+1+\binom{2\phi+1}{2}+\binom{2\phi+1}{3}+\ldots+\binom{2\phi+1}{\phi}$$
$$=2^{2\phi}-1=2^{\theta-1}-1.$$

Hence the lowest weight of a perpetuant is $2^{\theta-1}-1$, when θ is >2. The generating function is thus

$$\frac{z^{2^{\theta-1}-1}}{(1-z^2)(1-z^3)(1-z^4)\ldots(1-z^\theta)}.$$

The actual form of a perpetuant of degree θ has been shown by MacMahon to be

$$(\theta^{\kappa_\theta+1},\overline{\theta-1}^{\kappa_{\theta-1}+1},\overline{\theta-2}^{\kappa_{\theta-2}+2},\overline{\theta-3}^{\kappa_{\theta-3}+4},\ldots 3^{\kappa_3+2^{\theta-4}},2^{\kappa_2}),$$

$\kappa_\theta, \kappa_{\theta-1}, \ldots\kappa_2$ being given any zero or positive integer values.

Simultaneous Seminvariants of two Binary Forms.—Taking the two forms to be

$$a_0x_1^p+pa_1x_1^{p-1}x_2+p(p-1)a_2x_1^{p-2}x_2^2+\ldots+a_px_2^p,$$
$$b_0x_1^q+qb_1x_1^{q-1}x_2+q(q-1)b_2x_1^{q-2}x_2^2+\ldots+b_qx_2^q,$$

every leading coefficient of a simultaneous covariant vanishes by the operation of

$$\Omega_a+\Omega_b=a_0\frac{d}{da_1}+a_1\frac{d}{da_2}+\ldots+a_{p-1}\frac{d}{da_p}+b_0\frac{d}{db_1}+b_1\frac{d}{db_2}+\ldots+b_{q-1}\frac{d}{db_q}.$$

Observe that we may employ the principle of suffix diminution to obtain from any seminvariant one appertaining to a $p-1^{ic}$ and a $q-1^{ic}$, and that suffix augmentation produces a portion of a higher seminvariant, the degree in each case remaining unaltered. Remark, too, that we are in association with non-unitary symmetric functions of two systems of quantities which will be denoted by partitions in brackets $(\ )_a$, $(\ )_b$ respectively. Solving the equation

$$(\Omega_a+\Omega_b)u=0,$$

by the ordinary theory of linear partial differential equations, we obtain $p+q+1$ independent solutions, of which p appertain to $\Omega_a u=0$, q to $\Omega_b u=0$; the remaining one is $J_{ab}=a_0b_1-a_1b_0$, the leading coefficient of the Jacobian of the two forms. This constitutes an algebraically complete system, and, in terms of its members, all seminvariants can be rationally expressed. A similar theorem holds in the case of any number of binary forms, the mixed seminvariants being derived from the Jacobians of the several pairs of forms. If the seminvariant be of degrees θ, θ' in the coefficients, the forms of orders p, q respectively, and the weight w, the degree of the covariant in the variables will be $p\theta+q\theta'-2w=\epsilon$, an easy generalization of the theorem connected with a single form.

The general term of a seminvariant of degrees θ, θ' and weight w will be

$$a_0^{\rho_0}a_1^{\rho_1}a_2^{\rho_2}\dots a_p^{\rho_p}b_0^{\sigma_0}b_1^{\sigma_1}b_2^{\sigma_2}\dots b_q^{\sigma_q}$$

where $\quad \sum_1^p\rho_s=\theta,\ \sum_1^q\sigma_s=\theta'$ and $\sum_1^p s\rho_s+\sum_1^q s\sigma_s=w.$

The number of such terms is the number of partitions of w into $\theta+\theta'$ parts, the part magnitudes, in the two portions, being limited not to exceed p and q respectively. Denote this number by $(w;\theta,p;\theta',q)$. The number of linearly independent seminvariants of the given type will then be denoted by

$$(w;\theta,p;\theta',q)-(w-1;\theta,p;\theta',q);$$

and will be given by the coefficient of $a^\theta b^{\theta'}z^w$ in

$$\frac{1-z}{1-a.1-az.1-az^2.\dots1-az^p.1-b.1-bz.1-bz^2\dots1-bz^q};$$

that is, by the coefficient of z^w in

$$\frac{1-z^{p+1}.1-z^{p+2}.\dots1-z^{p+\theta}.1-z^{q+1}.1-z^{q+2}.\dots1-z^{q+\theta'}}{1-z.1-z^2.1-z^3.\dots1-z^\theta.1-z^2.1-z^3.\dots1-z^{\theta'}};$$

which preserves its expression when θ and p and θ' and q are separately or simultaneously interchanged.

Taking the first generating function, and writing $az^p, bz^q, \frac{1}{z^2}$ for a, b, and z respectively, we obtain the coefficient of

$$a^\theta b^{\theta'}z^{p\theta+q\theta'-2w},\ \text{that is of } a^\theta b^{\theta'}z^\epsilon,\ \text{in}$$

$$\frac{1-z^{-2}}{1-az^p.1-az^{p-2}.\dots1-az^{-p+2}.1-az^{-p}.1-bz^q.1-bz^{q-2}.\dots1-bz^{-q+2}.1-bz^{-q}};$$

the unreduced generating function which enumerates the covariants of degrees θ, θ' in the coefficients and order ϵ in the variables. Thus, for two linear forms, $p=q=1$, we find

$$\frac{1-z^{-2}}{1-az.1-az^{-1}.1-bz.1-bz^{-1}},$$

the positive part of which is

$$\frac{1}{1-az.1-bz.1-ab};$$

establishing the ground forms of degrees-order $(1,0;1)$, $(0,1;1)$, $(1,1;0)$, viz.:—the linear forms themselves and their Jacobian J_{ab}. Similarly, for a linear and a quadratic, $p=1, q=2$, and the reduced form is found to be

$$\frac{1-a^2b^2z^0}{1-az.1-bz^2.1-abz.1-b^2.1-a^2b},$$

where the denominator factors indicate the forms themselves, their Jacobian, the invariant of the quadratic and their resultant; connected, as shown by the numerator, by a syzygy of degrees-order $(2,2;2)$.

The complete theory of the perpetuants appertaining to two or more forms of infinite order has not yet been established. For two forms the seminvariants of degrees $1,1$ are enumerated by $\frac{1}{1-z}$, and the only one which is reducible is a_0b_0 of weight zero; hence the perpetuants of degrees $1,1$ are enumerated by

$$\frac{1}{1-z}-1=\frac{z}{1-z};$$

and the series is evidently

$$\begin{gathered}a_0b_1-a_1b_0,\\ a_0b_2-a_1b_1+a_2b_0,\\ a_0b_3-a_1b_2+a_2b_1-a_3b_0,\\ \cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\end{gathered}$$

one for each of the weights 1, 2, 3, ... *ad infin.*

For the degrees 1, 2, the asyzygetic forms are enumerated by $\frac{1}{1-z.1-z^2}$, and the actual forms for the first three weights are

$$\begin{gathered}a_0b_0^2,\\ (a_0b_1-a_1b_0)b_0,\\ (a_0b_2-a_1b_1+a_2b_0)b_0,\\ a_0(b_1^2-2b_0b_2),\\ (a_0b_3-a_1b_2+a_2b_1-a_3b_0)b_0,\\ a_0(b_1b_2-3b_0b_3)-a_1(b_1^2-2b_0b_2);\end{gathered}$$

amongst these forms are included all the asyzygetic forms of degrees 1, 1, multiplied by b_0, and also all the perpetuants of the second binary form multiplied by a_0; hence we have to subtract from the generating function $\frac{1}{1-z}$ and $\frac{z^2}{1-z^2}$, and we obtain the generating function of perpetuants of degrees 1, 2

$$\frac{1}{1-z.1-z^2}-\frac{1}{1-z}-\frac{z^2}{1-z^2}=\frac{z^3}{1-z.1-z^2}.$$

The first perpetuant is the last seminvariant written, viz.:—

$$a_0(b_1b_2-3b_0b_3)-a_1(b_1^2-2b_0b_2),$$

or, in partition notation,

$$a_0(21)_b-(1)_a(2)_b;$$

and, in this form, it is at once seen to satisfy the partial differential equation. It is important to notice that the expression

$$(\theta)_a(\theta'1^s)_b-(\theta1)_a(\theta'1^{s-1})_b+(\theta1^2)_a(\theta'1^{s-2})_b-\dots\pm(\theta1^s)_a(\theta')_b$$

denotes a seminvariant, if θ, θ', be neither of them unity, for, after operation, the terms destroy one another in pairs; when $\theta=0$, $(\theta)_a$ must be taken to denote a_0 and so for θ'. In general it is a seminvariant of degrees θ, θ', and weight $\theta+\theta'+s$; to this there is an exception, viz., when $\theta=0$, or when $\theta'=0$, the corresponding partial degrees are 1 and 1. When $\theta=\theta'=0$, we have the general perpetuant of degrees 1, 1. There is a still more general form of seminvariant; we may have instead of θ, θ' any collections of non-unitary integers not exceeding θ, θ' in magnitude respectively. *Ex. gr.*

$$\begin{aligned}&(2^{\lambda_2}3^{\lambda_3}\dots\theta^{\lambda_\theta})_a(1^s2^{\mu_2}3^{\mu_3}\dots\theta'^{\mu_{\theta'}})_b\\ &-(12^{\lambda_2}3^{\lambda_3}\dots\theta^{\lambda_\theta})_a(1^{s-1}2^{\mu_2}3^{\mu_3}\dots\theta'^{\mu_{\theta'}})_b\\ &+(1^22^{\lambda_2}3^{\lambda_3}\dots\theta^{\lambda_\theta})_a(1^{s-2}2^{\mu_2}3^{\mu_3}\dots\theta'^{\mu_{\theta'}})_b\\ &-\ .\ .\ .\ .\\ &(-)^s(1^s2^{\lambda_2}3^{\lambda_3}\dots\theta^{\lambda_\theta})_a(2^{\mu_2}3^{\mu_3}\dots\theta'^{\mu_{\theta'}})_b,\end{aligned}$$

is a seminvariant; and since these forms are clearly enumerated by

$$\frac{1}{1-z.1-z^2.\dots1-z^\theta.1-z^2.1-z^3.\dots1-z^{\theta'}},$$

an expression which also enumerates the asyzygetic seminvariants, we may regard the form, written, as denoting the general form of asyzygetic seminvariant; a very important conclusion. For the case in hand, from the simplest perpetuant of degrees 1, 2, we derive the perpetuants of weight w,

$$\begin{gathered}a_0(21^{w-2})_b-a_1(21^{w-3})_b+a_2(21^{w-4})_b-\dots\pm a_{w-2}(2)_b,\\ a_0(2^21^{w-4})_b-a_1(2^21^{w-5})_b+a_2(2^21^{w-6})_b-\dots\pm a_{w-4}(2^2)_b,\\ a_0(2^31^{w-6})_b-a_1(2^31^{w-7})_b+a_2(2^31^{w-8})_b-\dots\pm a_{w-6}(2^3)_b,\\ \cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\end{gathered}$$

a series of $\frac{1}{2}(w-2)$ or of $\frac{1}{2}(w-1)$ forms according as w is even or uneven. Their number for any weight w is the number of ways of composing $w-3$ with the parts 1, 2, and thus the generating function is verified. We cannot, by this method, easily discuss the perpetuants of degrees 2, 2, because a syzygy presents itself as early as weight 2. It is better now to proceed by the method of Stroh.

We have the symbolic expression of a seminvariant,

$$\frac{1}{w!}(\sigma_1\alpha_1+\sigma_2\alpha_2+\dots+\sigma_\theta\alpha_\theta+\tau_1\beta_1+\tau_2\beta_2+\dots+\tau_{\theta'}\beta_{\theta'})^w$$

where

$$\frac{\alpha_1^s}{s!}=\frac{\alpha_2^s}{s!}=\dots=a_s;\ \frac{\beta_1^s}{s!}=\frac{\beta_2^s}{s!}=\dots=b_s;$$

and $\quad \sigma_1+\sigma_2+\dots+\sigma_\theta+\tau_1+\tau_2+\dots+\tau_{\theta'}=0.$

Proceeding as we did in the case of the single binary form we find that for a given total degree $\theta+\theta'$, the condition which expresses reducibility is of total degree $2^{\theta+\theta'-1}-1$ in the coefficients σ and τ; combining this with the knowledge of the generating function of asyzygetic forms of degrees θ, θ', we find that the perpetuants of these degrees are enumerated by

$$\frac{z^{2^{\theta+\theta'-1}-1}}{1-z.1-z^2.1-z^3.\dots1-z^\theta.1-z^2.1-z^3.\dots1-z^{\theta'}},$$

and this is true for $\theta+\theta'=2$ as well as for other values of $\theta+\theta'$ (compare the case of the single binary form).

Observe that, if there be more than two binary forms, the weight of the simplest perpetuant of degrees θ, θ', θ'',... is $2^{\theta+\theta'+\theta''+\dots-1}-1$, as can be seen by reasoning of a similar kind.

To obtain information concerning the actual forms of the perpetuants, write

$$(1+\sigma_1x)(1+\sigma_2x)\dots(1+\sigma_\theta x)=1+A_1x+A_2x^2+\dots+A_\theta x^\theta$$
$$(1+\tau_1x)(1+\tau_2x)\dots(1+\tau_{\theta'}x)=1+B_1x+B_2x^2+\dots+B_{\theta'}x^{\theta'}$$

where $$A_1+B_1=0.$$

For the case $\theta=1$, $\theta'=1$, the condition is

$$\sigma_1\tau_1=A_1B_1=0,$$

which, since $A_1+B_1=0$, is really a condition of weight unity. For $w=1$ the form is $A_1a_1+B_1b_1$, which we may write $a_0b_1-a_1b_0=a_0(1)_b-(1)_ab_0$; the remaining perpetuants, enumerated by $\frac{z}{1-z}$, have been set forth above.

For the case $\theta=1$, $\theta'=2$, the condition is $\sigma_1\tau_1\tau_2=A_1B_2=0$; and the simplest perpetuant, derived directly from the product A_1B_2, is $(1)_a(2)_b-(21)_b$; the remainder of those enumerated by $\frac{z^3}{1-z.1-z^2}$ may be represented by the form

$$(1^{\lambda_1+1})_a(2^{\mu_2+1})_b-(1^{\lambda_1})_a(2^{\mu_2+1}1)_b+\dots\pm(2^{\mu_2+1}1^{\lambda_1+1})_b;$$

λ_1 and μ_2 each assuming all integer (including zero) values. For the case $\theta=\theta'=2$, the condition is

$$\sigma_1\sigma_2\tau_1\tau_2(\sigma_1+\sigma_2)(\sigma_1+\tau_1)(\sigma_1+\tau_2)=-A_2^2B_1B_2-A_1A_2B_2^2=0.$$

To represent the simplest perpetuant, of weight 7, we may take as base either $A_2^2B_1B_2$ or $A_1A_2B_2^2$, and since $A_1+B_1=0$ the former is equivalent to $A_1A_2^2B_2$ and the latter to $A_2B_1B_2^2$; so that we have, apparently, a choice of four products. $A_2^2B_1B_2$ gives $(2^2)_a(21)_b-(2^21)_a(2)_b$, and $A_1A_2^2B_2$, $(2^21)_a(2)_b-(2^2)_a(21)_b$; these two merely differ in sign; and similarly $A_2B_1B_2^2$ yields $(2)_a(2^21)_b-(21)_a(2^2)_b$, and that due to $A_1A_2B_2^2$ merely differs from it in sign. We will choose from the forms in such manner that the product of letters A is either a power of A_1, or does not contain A_1; this rule leaves us with $A_2^2B_1B_2$ and $A_2B_1B_2^2$; of these forms we will choose that one which in letters B is earliest in ascending dictionary order; this is $A_2^2B_1B_2$, and our earliest perpetuant is

$$(2^2)_a(21)_b-(2^21)_a(2)_b,$$

and thence the general form enumerated by the generating function $\frac{z^7}{(1-z)(1-z^2)^2}$ is

$$(2^{\lambda_2+2})_a(2^{\mu_2+1}1^{\mu_1+1})_b-(2^{\lambda_2+2}1)_a(2^{\mu_2+1}1^{\mu_1})_b+\dots$$
$$\pm(2^{\lambda_2+2}1^{\mu_1+1})_a(2^{\mu_2+1})_b.$$

For the case $\theta=1$, $\theta'=3$ the condition is

$$\sigma_1\tau_1\tau_2\tau_3(\sigma_1+\tau_1)(\sigma_1+\tau_2)(\sigma_1+\tau_3)=A_1B_3^2+A_1^2B_2B_3=0.$$

By the rules adopted we take $A_1^2B_2B_3$, which gives

$$(1^2)_a(32)_b-(1)_a(321)_b+a_0(321^2)_b,$$

the simplest perpetuant of weight 7; and thence the general form enumerated by the generating function

$$\frac{z^7}{1-z.1-z^2.1-z^3},$$

viz.:—$(1^{\lambda_1+2})_a(3^{\mu_3+1}2^{\mu_2+1})_b-\dots\pm a_0(3^{\mu_3+1}2^{\mu_2+1}1^{\lambda_1+2})_b$,

For the case $\theta=2$, $\theta'=3$, the condition is

$$\sigma_1\sigma_2\tau_1\tau_2\tau_3(\sigma_1+\sigma_2)(\sigma_1+\tau_1)(\sigma_1+\tau_2)(\sigma_1+\tau_3)(\sigma_2+\tau_1)(\sigma_2+\tau_2)(\sigma_2+\tau_3)$$
$$\times(\tau_1+\tau_2)(\tau_1+\tau_3)(\tau_2+\tau_3)=0.$$

The calculation results in

$$-A_2^4B_3B_2B_1^2+2A_2^3B_3B_2^2B_1^2-A_2^2B_3B_2^3B_1^2+A_2^4B_3^2B_1-2A_2^3B_3^2B_2B_1$$
$$-A_2^2B_3^2B_2B_1^3+A_2^2B_3^2B_2^2B_1+A_2B_3B_2^3B_1^4+A_2^2B_3^2B_1^5-2A_2B_3^2B_2B_1^5$$
$$+A_2B_3^4B_1=0.$$

By the rules we select the product $A_2^4B_3B_2B_1^2$, giving the simplest perpetuant of weight 15, viz.:—

$$(2^4)_a(321^2)_b-(2^41)_a(321)_b+(2^41^2)_a(32)_b;$$

and thence the general form

$$(2^{\lambda_2+4})_a(3^{\mu_3+1}2^{\mu_2+1}1^{\mu_1+2})_b-\dots\pm(2^{\lambda_2+4}1^{\mu_1+2})_a(3^{\mu_3+1}2^{\mu_2+1})_b,$$

due to the generating function

$$\frac{z^{15}}{(1-z)(1-z^2)^2(1-z^3)}.$$

For the case $\theta=1$, $\theta'=4$, the condition is

$$\sigma_1\tau_1\tau_2\tau_3\tau_4(\sigma_1+\tau_1)(\sigma_1+\tau_2)(\sigma_1+\tau_3)(\sigma_1+\tau_4)\Pi(\tau_s+\tau_t)=0;$$

the calculation gives

$$A_1B_4(A_1^2B_2+A_1B_3+B_4)(-B_3^2-A_1B_2B_3-A_1^2B_4)=0.$$

Selecting the product $A_1^4B_4B_3B_2^2$, we find the simplest perpetuant

$$(1^4)_a(432^2)_b-(1^3)_a(432^21)_b+(1^2)_a(432^21^2)_b-(1)_a(432^21^3)_b$$
$$+a_0(432^21^4)_b,$$

and thence the general form

$$(1^{\lambda_1+4})_a(4^{\mu_4+1}3^{\mu_3+1}2^{\mu_2+2})_b-\dots\pm a_0(4^{\mu_4+1}3^{\mu_3+1}2^{\mu_2+2}1^{\lambda_1+4})_b,$$

due to the generating function

$$\frac{z^{13}}{1-z.1-z^2.1-z^3.1-z^4}.$$

The series may be continued, but the calculations soon become very laborious.

Three Binary Forms.—Taking the partial degrees of a seminvariant of three binary forms to be θ, θ', θ'', an easy generalization of the foregoing leads to the generating function

$$\frac{1}{(1-z)(1-z^2)\dots(1-z^\theta)(1-z)(1-z^2)\dots(1-z^{\theta'})(1-z)(1-z^2)\dots(1-z^{\theta''})},$$

of the asyzygetic forms. If we place as numerator to this fraction $z^{2^{\theta+\theta'+\theta''-1}-1}$ we obtain the generator of the perpetuants. To obtain representative forms of perpetuants we require a general solution of the partial differential equation

$$\left(a_0\frac{d}{da_1}+a_1\frac{d}{da_2}+\dots\right)+\left(b_0\frac{d}{db_1}+b_1\frac{d}{db_2}+\dots\right)+$$
$$\left(c_0\frac{d}{dc_1}+c_1\frac{d}{dc_2}+\dots\right)=0,$$

or say $$\Omega_a+\Omega_b+\Omega_c=0.$$

The general form of solution of $\Omega_b+\Omega_c=0$ we have seen to be

$$(2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^s2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c$$
$$-(12^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^{s-1}2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c+\dots$$

the expression consisting of $s+1$ terms and the coefficients being alternately $+1$ and -1. Denote this by

$$\left|(2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^s2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c\right|.$$

Now construct the expression

$$(1^t2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^s2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c$$
$$-\binom{t+1}{1}(1^{t+1}2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^{s-1}2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c$$
$$+\binom{t+2}{2}(1^{t+2}2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^{s-2}2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c$$
$$-\ .\ \ .\ \ .\ \ .$$

continued to $s+1$ terms and denote it by

$$\left|(1^t2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^s2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c\right|,$$

and verify that, if it be operated upon by $\Omega_b+\Omega_c$, the effect is to change t into $t-1$. The consequence of this is that if we form the expression

$$(2^{\kappa_2}3^{\kappa_3}\dots\theta^{\kappa_\theta})_a\left|(1^t2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^s2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c\right|$$
$$-(12^{\kappa_2}3^{\kappa_3}\dots\theta^{\kappa_\theta})_a\left|(1^{t-1}2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^s2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c\right|$$
$$+(1^22^{\kappa_2}3^{\kappa_3}\dots\theta^{\kappa_\theta})_a\left|(1^{t-2}2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^s2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c\right|$$
$$-\ .\ \ .\ \ .\ \ .$$

continued to $t+1$ terms, we obtain a solution of

$$\Omega_a+\Omega_b+\Omega_c=0.$$

To find the enumerating generating function of these forms suppose θ, θ', and θ'' to be in ascending order of magnitude, and denote the form by

$$\left|(2^{\kappa_2}3^{\kappa_3}\dots\theta^{\kappa_\theta})_a(1^{\lambda_1}2^{\lambda_2}3^{\lambda_3}\dots\theta'^{\lambda_{\theta'}})_b(1^{\mu_1}2^{\mu_2}3^{\mu_3}\dots\theta''^{\mu_{\theta''}})_c\right|.$$

In constructing this we have a choice of two places in which to place the part 1, three places in which to place the part 2, and so on; hence the generating function is

$$\frac{1}{1-z.1-z^2.1-z^3\dots1-z^\theta.1-z.1-z^2.1-\dots-z^{\theta'}.1-z^2.1-z^3\dots1-z^{\theta''}},$$

precisely that of the asyzygetic forms. Hence the constructed expression may be taken to be the general expression of an asyzygetic form. This idea is easily generalizable to the case of any number of binary forms. Stroh's form of seminvariant being

$$\frac{1}{w!}(\sigma_1\alpha_1+\sigma_2\alpha_2+\dots+\sigma_\theta\alpha_\theta+\tau_1\beta_1+\tau_2\beta_2+\dots+\tau_{\theta'}\beta_{\theta'}+v_1\gamma_1$$
$$+v_2\gamma_2+\dots+v_{\theta''}\gamma_{\theta''})^w,$$

the first case to consider is $\theta=1$, $\theta'=1$, $\theta''=1$, leading to the condition $\sigma_1\tau_1 v_1 = A_1B_1C_1 = 0$, where $A_1 + B_1 + C_1 = 0$. We have a choice of six products for our base, viz.,

$$B_1^2C_1,\ B_1C_1^2,\ A_1^2C_1,\ A_1C_1^2,\ A_1^2B_1,\ A_1B_1^2,$$

and these yield respectively

$$\begin{array}{ll} |\ a_0(1^2)_b(1)_c\ |, & |\ a_0(1)_b(1^2)_c\ |, \\ |\ (1^2)_a b_0\ (1)_c\ |, & |\ (1)_a b_0\ (1^2)_c\ |, \\ |\ (1^2)_a(1)_b\, c_0\ |, & |\ (1)_a(1^2)_b c_0\ |. \end{array}$$

Taking the product $A_1^2B_1$ and the corresponding form

$$|\ (1^2)_a(1)_b c_0\ |$$

we find

$$\begin{aligned} &|\ (1)_a^2(1)_b\ |\ c_0 - |\ (1)_a(1)_b\ |\ c_1 + |\ a_0(1)_b\ |\ c_2 \\ &= (a_2b_1 - 3a_3b_0)c_0 - (a_1b_1 - 2a_2b_0)c_1 + (a_0b_1 - a_1b_0)c_2, \end{aligned}$$

the simplest perpetuant of the kind; the general form, given by the generator $\frac{z^3}{(1-z)^2}$, being

$$\left|(1^{\lambda_2+2})_a(1^{\lambda_1+1})_b c_0\right|.$$

Similarly for 4 binary forms the simplest perpetuant, of degrees 1, 1, 1, 1, is (corresponding to product $A_1^4B_1^2C_1$)

$$|\ (1^4)_a(1^2)_b(1)_c d_0\ |;$$

and has the expression

$$\begin{aligned} &a_0(b_2c_1d_4 - 3b_3c_0d_4) \\ &+ a_1(b_1c_1d_4 + 2b_2c_0d_4 - b_2c_1d_3 + 3b_3c_0d_3) \\ &+ a_2(b_0c_1d_4 - b_1c_0d_4 + 2b_1c_1d_3 - 4b_2c_0d_3 + b_2c_1d_2 - 3b_3c_0d_2) \\ &+ a_3(-3b_0c_1d_3 + 3b_1c_0d_3 - 3b_1c_1d_2 + 6b_2c_0d_2 - b_2c_1d_1 + 3b_3c_0d_1) \\ &+ a_4(6b_0c_1d_2 - 6b_1c_0d_2 + 4b_1c_1d_1 - 8b_2c_0d_1 + b_2c_1d_0 - 3b_3c_0d_0) \\ &+ a_5(-10b_0c_1d_1 + 10b_1c_0d_1 - 5b_1c_1d_0 + 10b_2c_0d_0) \\ &+ a_6(+15b_0c_1d_0 - 15b_1c_0d_0). \end{aligned}$$

V. RESTRICTED SUBSTITUTIONS.

We may regard the factors of a binary n^{ic} equated to zero as denoting n straight lines through the origin, the co-ordinates being Cartesian and the axes inclined at any angle. Taking the variables to be x, y and affecting the linear transformation

$$\begin{aligned} x &= \lambda_1 X + \mu_1 Y, \\ y &= \lambda_2 X + \mu_2 Y, \end{aligned}$$

so that

$$\frac{y}{x} = \frac{\lambda_2 + \mu_2\frac{Y}{X}}{\lambda_1 + \mu_1\frac{Y}{X}},\quad \frac{Y}{X} = \frac{\lambda_1\frac{y}{x} - \lambda_2}{\mu_2 - \mu_1\frac{y}{x}};$$

it is seen that the two lines, on which lie (x, y), (X, Y), have a definite projective correspondence. The linear transformation replaces points on lines through the origin by corresponding points on projectively corresponding lines through the origin; it therefore replaces a pencil of lines by another pencil, which corresponds projectively, and harmonic and other properties of pencils which are unaltered by linear transformation we may expect to find indicated in the invariant system. Or, instead of looking upon a linear substitution as replacing a pencil of lines by a projectively corresponding pencil retaining the same axes of co-ordinates, we may look upon the substitution as changing the axes of co-ordinates retaining the same pencil. Then a binary n^{ic}, equated to zero, represents n straight lines through the origin, and the x, y, of any line through the origin are given constant multiples of the sines of the angles which that line makes with two fixed lines, the axes of co-ordinates. As new axes of co-ordinates we may take any other pair of lines through the origin, and for the X, Y corresponding to x, y any new constant multiples of the sines of the angles which the line makes with the new axes. The substitution for x, y in terms of X, Y is the most general linear substitution in virtue of the four degrees of arbitrariness introduced, viz., two by the choice of axes, two by the choice of multiples. If now the a^{ic} denote a given pencil of lines, an invariant is the criterion of the pencil possessing some particular property which is independent alike of the axes and of the multiples, and a covariant expresses that the pencil of lines which it denotes is a fixed pencil whatever be the axes or the multiples.

Besides the invariants and covariants, hitherto studied, there are others which appertain to particular cases of the general linear substitution. Thus, what have been called, seminvariants are not all of them invariants for the general substitution, but are invariants for the particular substitution

$$\begin{aligned} x_1 &= \lambda_1\xi_1 + \mu_1\xi_2, \\ x_2 &= \qquad\quad \mu_2\xi_2. \end{aligned}$$

Again, in plane geometry, the most general equations of substitution which change from old axes inclined at ω to new axes inclined at $\omega' = \beta - \alpha$, and inclined at angles α, β to the old axis of x, without change of origin, are

$$\begin{aligned} x &= \frac{\sin(\omega - \alpha)}{\sin\omega}X + \frac{\sin(\omega - \beta)}{\sin\omega}Y, \\ y &= \frac{\sin\alpha}{\sin\omega}X \qquad + \frac{\sin\beta}{\sin\omega}Y, \end{aligned}$$

a transformation of modulus

$$\frac{\sin\omega'}{\sin\omega}.$$

The theory of invariants originated in the discussion, by Boole, of this system so important in geometry. Of the quadratic

$$ax^2 + 2bxy + cy^2,$$

he discovered the two invariants

$$ac - b^2,\ a - 2b\cos\omega + c,$$

and it may be verified that, if the transformed of the quadratic be

$$\begin{aligned} AX^2 + 2BXY &+ CY^2, \\ AC - B^2 &= \left(\frac{\sin\omega'}{\sin\omega}\right)^2(ac - b^2), \\ A - 2B\cos\omega' + C &= \left(\frac{\sin\omega'}{\sin\omega}\right)^2(a - 2b\cos\omega + c). \end{aligned}$$

The fundamental fact that he discovered was the invariance of $x^2 + 2\cos\omega\, xy + y^2$, viz.—

$$x^2 + 2\cos\omega\, xy + y^2 = X^2 + 2\cos\omega' XY + Y^2,$$

from which it appears that the Boolian invariants of $ax^2 + 2bxy + y^2$ are nothing more than the full invariants of the simultaneous quadratics

$$ax^2 + 2bxy + y^2,\ x^2 + 2\cos\omega\, xy + y^2,$$

the word invariant including here covariant. In general the Boolian system, of the general n^{ic}, is coincident with the simultaneous system of the n^{ic} and the quadratic $x^2 + 2\cos\omega\, xy + y^2$.

Orthogonal System.—In particular, if we consider the transformation from one pair of rectangular axes to another pair of rectangular axes we obtain an orthogonal system which we will now briefly inquire into. We have $\cos\omega' = \cos\omega = 0$ and the substitution

$$\begin{aligned} x_1 &= \cos\theta X_1 - \sin\theta X_2, \\ x_2 &= \sin\theta X_1 + \cos\theta X_2, \end{aligned}$$

with modulus unity. This is called the *direct* orthogonal substitution, because the sense of rotation from the axis of X_1 to the axis of X_2 is the same as that from that of x_1 to that of x_2. If the senses of rotation be opposite we have the skew orthogonal substitution

$$\begin{aligned} x_1 &= \cos\theta X_1 + \sin\theta X_2, \\ x_2 &= \sin\theta X_1 - \cos\theta X_2, \end{aligned}$$

of modulus -1. In both cases $\frac{d}{dx_1}$ and $\frac{d}{dx_2}$ are cogredient with x_1 and x_2; for, in the case of direct substitution,

$$\begin{aligned} \frac{d}{dx_1} &= \cos\theta\frac{d}{dX_1} - \sin\theta\frac{d}{dX_2}, \\ \frac{d}{dx_2} &= \sin\theta\frac{d}{dX_1} + \cos\theta\frac{d}{dX_2}; \end{aligned}$$

and for skew substitution

$$\begin{aligned} \frac{d}{dx_1} &= \cos\theta\frac{d}{dX_1} + \sin\theta\frac{d}{dX_2}, \\ \frac{d}{dx_2} &= \sin\theta\frac{d}{dX_1} - \cos\theta\frac{d}{dX_2}. \end{aligned}$$

Hence, in both cases, contragrediency and cogrediency are identical, and contravariants are included in covariants.

Consider the binary n^{ic}, $(a_1x_1 + a_2x_2)^n = a_x^n$, and the direct substitution

$$\begin{aligned} x_1 &= \lambda X_1 - \mu X_2, \\ x_2 &= \mu X_1 + \lambda X_2, \end{aligned}$$

where $\lambda^2 + \mu^2 = 1$; λ, μ replacing $\cos\theta$, $\sin\theta$ respectively. In the notation

$$a_x = a_1x_1 + a_2x_2,$$

observe that

$$\begin{aligned} a_a &= a_1^2 + a_2^2, \\ a_b &= a_1b_1 + a_2b_2. \end{aligned}$$

Suppose that

$$a_x = b_x = c_x = \ldots$$

is transformed into

$$A_X = B_X = C_X = \ldots$$

then of course $(AB) = (ab)$ the fundamental fact which appertains to the theory of the general linear substitution; now here we have additional and equally fundamental facts; for since

$$\begin{aligned} A_1 &= \lambda a_1 + \mu a_2,\ A_2 = -\mu a_1 + \lambda a_2, \\ A_A &= A_1^2 + A_2^2 = (\lambda^2 + \mu^2)(a_1^2 + a_2^2) = a_a; \\ A_B &= A_1B_1 + A_2B_2 = (\lambda^2 + \mu^2)(a_1b_1 + a_2b_2) = a_b; \\ (XA) &= X_1A_2 - X_2A_1 = (\lambda x_1 + \mu x_2)(-\mu a_1 + \lambda a_2) \\ &\quad - (-\mu x_1 + \lambda x_2)(\lambda a_1 + \mu a_2) = (\lambda^2 + \mu^2)(x_1a_2 - x_2a_1) = (xa); \end{aligned}$$

showing that, in the present theory, a_a, a_b, and (xa) possess the invariant property. Since $x_1^2+x_2^2=x_x$ we have six types of symbolic factors which may be used to form invariants and covariants, viz.—

$$(ab),\ a_a,\ a_b,\ (xa),\ a_x,\ x_x.$$

The general form of covariant is therefore

$$\begin{aligned}&(ab)^{h_1}(ac)^{h_2}(bc)^{h_3}\dots a_a^{i_1}b_b^{i_2}c_c^{i_3}\dots a_b^{j_1}a_c^{j_2}b_a^{j_3}\dots\\&\times(xa)^{k_1}(xb)^{k_2}(xc)^{k_3}\dots a_x^{l_1}b_x^{l_2}c_x^{l_3}\dots x_x^m\\&=(AB)^{h_1}(AC)^{h_2}(BC)^{h_3}\dots A_A^{i_1}B_B^{i_2}C_C^{i_3}\dots A_B^{j_1}A_C^{j_2}B_C^{j_3}\dots\\&\times(XA)^{k_1}(XB)^{k_2}(XC)^{k_3}\dots A_X^{l_1}B_X^{l_2}C_X^{l_3}\dots X_X^m.\end{aligned}$$

If this be of order ϵ and appertain to an n^{ic}

$$\begin{gathered}\Sigma k+\Sigma l+2m=\epsilon,\\ h_1+h_2+\dots+2i_1+j_1+j_2+\dots+k_1+l_1=n,\\ h_1+h_3+\dots+2i_2+j_1+j_3+\dots+k_2+l_2=n,\\ h_2+h_3+\dots+2i_3+j_2+j_3+\dots+k_3+l_3=n;\\ \cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\end{gathered}$$

viz., the symbols $a, b, c,\dots$ must each occur n times. It may denote a simultaneous orthogonal invariant of forms of orders $n_1, n_2, n_3,\dots$; the symbols must then present themselves $n_1, n_2, n_3\dots$ times respectively. The number of different symbols $a, b, c,\dots$ denotes the degree θ of the covariant in the coefficients. The coefficients of the covariants are homogeneous, but not in general isobaric functions, of the coefficients of the original form or forms. Of the above general form of covariant there are important transformations due to the symbolic identities:—

$$(ab)^2=a_ab_b-a_b^2;\ (xa)^2=a_ax_x-a_x^2;$$

as a consequence any even power of a determinant factor may be expressed in terms of the other symbolic factors, and any uneven power may be expressed as the product of its first power and a function of the other symbolic factors. Hence in the above general form of covariant we may suppose the exponents

$$h_1,\ h_2,\ h_3,\dots k_1,\ k_2,\ k_3,\dots$$

of the determinant factors to be, each of them, either zero or unity. Or, if we please, we may leave the determinant factors untouched and consider the exponents $j_1, j_2, j_3,\dots l_1, l_2, l_3,\dots$ to be, each of them, either zero or unity. Or, lastly, we may leave the exponents h, k, j, l untouched and consider the product

$$a_a^{i_1}b_b^{i_2}c_c^{i_3}\dots x_x^m,$$

to be reduced either to the form g_g^i where g is a symbol of the series $a, b, c,\dots$ or to a power of x_x. To assist us in handling the symbolic products we have not only the identity

$$(ab)c_x+(bc)a_x+(ca)b_x=0,$$

but also

$$\begin{gathered}(ab)x_x+(bx)a_x+(xa)b_x=0,\\(ab)a_c+(bc)a_a+(ca)a_b=0,\end{gathered}$$

and many others which may be derived from these in the manner which will be familiar to students of the works of Aronhold, Clebsch, and Gordan. Previous to continuing the general discussion it is useful to have before us the orthogonal invariants and covariants of the binary linear and quadratic forms.

For the linear form $\bar a_0x_1+\bar a_1x_2=a_x=b_x$ there are four fundamental forms,

(i.) $a_x=\bar a_0x_1+\bar a_1x_2$ of degree-order $(1,1)$,
(ii.) $x_x=x_1^2+x_2^2$ „ $(0,2)$,
(iii.) $(xa)=\bar a_1x_1-\bar a_0x_2$ „ $(1,1)$,
(iv.) $a_a=\bar a_0^2+\bar a_1^2$ „ $(2,0)$,

(iii.) and (iv.) being the linear covariant and the quadrinvariant respectively. Every other concomitant is a rational integral function of these four forms. The linear covariant, obviously the Jacobian of a_x and x_x, is the line perpendicular to a_x, and the vanishing of the quadrinvariant a_a is the condition that a_x passes through one of the circular points at infinity. In general any pencil of lines, connected with the line a_x by descriptive or metrical properties, has for its equation a rational integral function of the four forms equated to zero.

For the quadratic $\bar a_0x_1^2+2\bar a_1x_1x_2+\bar a_2x_2^2$, we have

(i.) $a_x^2=\bar a_1x_1^2+2\bar a_1x_1x_2+\bar a_2x_2^2$,
(ii.) $x_x=x_1^2+x_2^2$,
(iii.) $(ab)^2=2(\bar a_0\bar a_2-\bar a_1^2)$,
(iv.) $a_a=\bar a_0+\bar a_2$,
(v.) $(xa)a_x=\bar a_1x_1^2+(\bar a_2-\bar a_0)x_1x_2-\bar a_1x_2^2$.

This is the fundamental system; we may, if we choose, replace $(ab)^2$ by $a_b^2=\bar a_0^2+2\bar a_1^2+\bar a_2^2$ since the identity $a_ab_b-a_b^2=(ab)^2$ shows the syzygetic relation

$$(\bar a_0+\bar a_2)^2-(\bar a_0^2+2\bar a_1^2+\bar a_2^2)=2(\bar a_0\bar a_2-\bar a_1^2).$$

There is no linear covariant, since it is impossible to form a symbolic product which will contain x once and at the same time appertain to a quadratic. (v.) is the Jacobian; geometrically it denotes the bisectors of the angles between the lines a_x^2, or, as we may say, the common harmonic conjugates of the lines a_x^2 and the lines x_x. The linear invariant a_a is such that, when equated to zero, it determines the lines a_x^2 as harmonically conjugate to the lines x_x; or, in other words, it is the condition that a_x^2 may denote lines at right angles.

To resume the general discussion we recall the relations

$$A_1=\lambda a_1+\mu a_2,\ A_2=-\mu a_1+\lambda a_2,$$

and put $\lambda=\lambda_1=\mu_2;\ =\mu=\lambda_2=-\mu_1;$

so that $A_1=a_\lambda=(a\mu),$

$$A_2=a_\mu=(\lambda a),$$

giving

$$\begin{aligned}\bar A_k&=A_1^{n-k}A_2^k=a_\lambda^{n-k}a_\mu^k\\&=(a\mu)^{n-k}a_\mu^k=a_\lambda^{n-k}(\lambda a)^k=(a\mu)^{n-k}(\lambda a)^k\\A_X^n&=(a_\lambda X_1+a_\mu X_2)^n=\left\{(a\mu)X_1+a_\mu X_2\right\}^n\\&=\left\{a_\lambda X_1+(\lambda a)X_2\right\}^n=\left\{(a\mu)X_1+(\lambda a)X_2\right\}^n;\end{aligned}$$

four forms of expression.

The polar process is available here to an enhanced degree. For put

$$f=a_x^m,\ \phi=(xa)^n,$$

we not only have

$$f_y^k=a_x^{m-k}a_y^k,$$

but also

$$\phi_y^k=(xa)^{n-k}(ya)^k;$$

and just as the substitution of x_1+ty_1, x_2+ty_2 for x_1, x_2 converts a_x into a_x+ta_y, the same substitution converts (xa) into $(xa)+t(ya)$, and the symbolic power

$$\{(xa)+t(ya)\}^n$$

may be regarded as the generator of polars of $(xa)^n$. Note also the results

$$\begin{aligned}\frac{1}{m}\left(y\frac{d}{dx}\right)a_x^m&=a_x^{m-1}(ya),\\\frac{1}{n}\left(\frac{d}{dx}y\right)(xa)^n&=(xa)^{n-1}a_y,\end{aligned}$$

where

$$y_1\frac{d}{dx_2}-y_2\frac{d}{dx_1}=\left(y\frac{d}{dx}\right)=-\left(\frac{d}{dx}y\right);$$

indicating processes analogous to the polar process by which

$$\begin{gathered}a_x^m\text{ is converted into }a_x^{m-k}(ya)^k,\\(xa)^n\text{ is converted into }(xa)^{n-k}a_y^k.\end{gathered}$$

Combining the processes we find that we are in possession of a process, equivalent to a compound partial differential operation, by which a_x^m can be converted into $a_x^{m-k_1-k_2}a_y^{k_1}(ya)^{k_2}$, and one also by which $(xa)^n$ can be converted into $(xa)^{n-k_1-k_2}(ya)^{k_1}a_y^{k_2}$.

We already know that the polar $a_x^{m-k}a_y^k$ satisfies the partial differential equation of the second order

$$\frac{\partial^2u}{\partial x_1\partial y_2}-\frac{\partial^2u}{\partial x_2\partial y_1}=0;$$

and the performance of the operation

$$\frac{1}{(m-k)k}\left(\frac{\partial^2}{\partial x_1\partial y_2}-\frac{\partial^2}{\partial x_2\partial y_1}\right)$$

has been termed the Ω process. As regards the new forms

$$u_1=a_x^{m-k}(ya)^k,\ u_2=(xa)^{n-k}a_y^k,$$

since

$$\begin{aligned}\frac{\partial^2u_1}{\partial x_1\partial y_1}&=(m-k)ka_x^{m-k-1}(ya)^{k-1}a_1a_2,\\\frac{\partial^2u_1}{\partial x_2\partial y_2}&=(m-k)ka_x^{m-k-1}(ya)^{k-1}(-a_1a_2),\\\frac{\partial^2u_2}{\partial x_1\partial y_1}&=(n-k)k(xa)^{n-k-1}a_y^{k-1}a_1a_2,\\\frac{\partial^2u_2}{\partial x_2\partial y_2}&=(n-k)k(xa)^{n-k-1}a_y^{k-1}(-a_1a_2),\end{aligned}$$

we find that they *both* satisfy the partial differential equation of the second order

$$\frac{\partial^2 u}{\partial x_1 \partial y_1} + \frac{\partial^2 u}{\partial x_2 \partial y_2} = 0;$$

and the operation indicated occupies the same position in regard to the new forms that the Ω process does in regard to polars.

Gordan finds it convenient sometimes to denote the Ω operation by $\begin{vmatrix} x_1 x_2 \\ y_1 y_2 \end{vmatrix} = (xy)$ symbolically. In the same symbolism the new process O is denoted by $x_1 y_1 + x_2 y_2 = x_y$.

Let $$\mathrm{O}(f) = \frac{1}{m.n}\left(\frac{\partial^2 f}{\partial x_1 \partial y_1} + \frac{\partial^2 f}{\partial x_2 \partial y_2}\right),$$

the operand being any form $p_x^m q_y^n$.

Then $$\mathrm{O}a_x^m (yb)^n = (ab) a_x^{m-1} (yb)^{n-1},$$

and thence $$\mathrm{O}^k a_x^m (yb)^n = (ab)^k a_x^{m-k} (yb)^{n-k};$$

also $$\mathrm{O}(ax)^m b_y^n = (ab)(ax)^{m-1} b_y^{n-1},$$

and thence $$\mathrm{O}^k (ax)^m b_y^n = (ab)^k (ax)^{m-k} b_y^{n-k},$$

which should be compared with the result

$$\Omega^k a_x^m b_y^n = (ab)^k a_x^{m-k} b_y^{n-k}.$$

Moreover, it is easy to see that $(xa)^m (ya)^n$ satisfies the Ω equation, and that

$$\Omega^k (xa)^m (yb)^n = (ab)^k (xa)^{m-k} (yb)^{n-k}.$$

We may catalogue results as follows :—

$$\begin{aligned}
\Omega^k a_x^m b_y^n &= (ab)^k a_x^{m-k} b_y^{n-k},\\
\mathrm{O}^k a_x^m b_y^n &= a_b^k a_x^{m-k} b_y^{n-k},\\
\Omega^k a_x^m (by)^n &= a_b^k a_x^{m-k} (by)^{n-k},\\
\mathrm{O}^k a_x^m (yb)^n &= (ab)^k a_x^{m-k} (yb)^{n-k},\\
\Omega^k (xa)^m b_y^n &= a_b^k (xa)^{m-k} y_b^{n-k},\\
\mathrm{O}^k (ax)^m b_y^n &= (ab)\ (ax)^{m-k} b_y^{n-k},\\
\Omega^k (xa)^m (yb)^n &= (ab)^k (xa)^{m-k} (yb)^{n-k},\\
\mathrm{O}^k (xa)^m (yb)^n &= a_b^k (xa)^{m-k} (yb)^{n-k}.
\end{aligned}$$

The important point is that we always obtain symbolic products when we operate with Ω or O on symbolic products. It is clear that we may write

$$\begin{aligned}
\Omega^k \mathrm{O}^l a_x^m b_y^n &= (ab)^k a_b^l a_x^{m-k-l} b_y^{n-k-l},\\
\Omega^k \mathrm{O}^l a_x^m (yb)^n &= (-)^k a_b^k (ab)^l a_x^{m-k-l} (yb)^{n-k-l},\\
\Omega^k \mathrm{O}^l (xa)^m b_y^n &= (-)^l a_b^k (ab)^l (xa)^{m-k-l} b_y^{n-k-l},\\
\Omega^k \mathrm{O}^l (xa)^m (yb)^n &= (ab)^k a_b^l (xa)^{m-k-l} (yb)^{n-k-l};
\end{aligned}$$

foreshadowing an extension of the process of transvection which will be reached later.

The co-polar processes, by which a_x^n is converted to $a_x^{n-k}(ya)^k$, and $(xa)^n$ to $(xa)^{n-k} a_y^k$, are representable by writing $x - ty$, $x_2 + ty_1$ for x_1, x_2 in a_x^n, and $x_1 + ty_2, x_2 - ty_1$ for x_1, x_2 in $(xa)^n$; for a_x^n becomes

$$\{a_x + t(ya)\}^n,$$

and $(xa)^n$ becomes

$$\{(xa) + ta_y\}^n.$$

The combined polar and co-polar process on a_x^n can be obtained by writing $x_1 + (yt), x_2 + y_t$ for x_1, x_2, and expanding in powers of t_1, t_2; for then a_x becomes $a_x + t_1(ya) + t_2 a_y$, the n^{th} power of which generates the functions; similarly if the function be $(xa)^n$ we can substitute $x_1 + t_y, x_2 + (ty)$ for x_1, x_2, converting (xa) into $(xa) + t_1(ya) + t_2 a_y$, and the n^{th} power generates the polar functions.

To find the polar and co-polar functions of the product

$$\mathrm{F} = a_x^m b_x^n = p_x^{m+n},$$

write $$\mathrm{F}_y^{k_1, k_2} = p_x^{m+n-k_1-k_2} (ya)^{k_1} p_y^{k_2}.$$

This, obviously, arises from p_x^{m+n} when we write $x_1 + (yt)$, $x_2 + y_t$ for x_1 and x_2 in p_x^{m+n}, and take the co-factor of $\binom{m+n}{k_1, k_2} t_1^{k_1} t_2^{k_2}$. Since

$$(p_x + t_1(yp) + t_2 p_y)^{m+n} = (a_x + t_1(ya) + t_2 a_y)^m (b_x + t_1(yb) + t_2 b_y)^n,$$

$$\binom{m+n}{k_1, k_2} \mathrm{F}_y^{k_1, k_2} = \text{coefficient of } t_1^{k_1} t_2^{k_2} \text{ in the product}$$

$$(a_x + t_1(ya) + t_2 a_y)^m (b_x + t_1(yb) + t_2 b_y)^n.$$

(ii.) in descending order as regards the exponents of b_y and (ya); (iii.) in ascending order in regard to the exponents of a_y, (yb), and b_x. We have then the notion of adjacent members, and we can show that the difference between any two adjacent members is either divisible by $(ab)(xy)$, $(ab)x_y$ or $(ab)y_x$, and the theory of the polar members may be proceeded with in the usual manner.

The process of transvection can be extended in the same way as the polar process. Of two forms

$$f=a_x^m,\ \phi=b_x^n$$

we define the transvectant of orders k, l to be

$$(f,\phi)^{k,l}=\left\{\Omega^k O^l a_x^m b_y^n\right\}_{y=x}$$
$$=(ab)^k a_b^l a_x^{m-k-l} b_x^{n-k-l};$$

and similarly

$$\left\{a_x^m,(xb)^n\right\}^{k,l}=(-)^k a_b^k (ab)^l a_x^{m-k-l}(xb)^{n-k-l},$$
$$\left\{(xa)^m,b_x^n\right\}^{k,l}=(-)^l a^k (ab)^l (xa)^{m-k-l} b_x^{n-k-l},$$
$$\left\{(xa)^m,(xb)^n\right\}^{k,l}=(ab)^k a_b^l (xa)^{m-k-l}(xb)^{n-k-l};$$

and if the forms be $\qquad \phi_x^m,\ \psi_x^n,$

$$(\phi_x^m,\psi_x^n)^{k,l}=(\phi\psi)^k \phi_\psi^l \phi_x^{m-k-l}\psi_x^{n-k-l};$$

and similarly

$$\left\{(x\phi)^m,(x\psi)^n\right\}^{k,l}=(\phi\psi)^k \phi_\psi^l (x\phi)^{m-k-l}(x\psi)^{n-k-l};$$

and the intermediate processes also in the same way. Taking as before $f=a_x^m$, $\phi=b_x^n$, we find that the process of transvection of order $k+l$ is equivalent to the performance of the differential operation

$$\left(\frac{\partial f}{\partial x_1}\frac{\partial \phi}{\partial x_2}-\frac{\partial f}{\partial x_2}\frac{\partial \phi}{\partial x_1}\right)^k\left(\frac{\partial f}{\partial x_1}\frac{\partial \phi}{\partial x_1}+\frac{\partial f}{\partial x_2}\frac{\partial \phi}{\partial x_2}\right)^l;$$

omitting a mere numerical factor. The multiplication of operations is, of course, symbolic, so that

$$\left(\frac{\partial f}{\partial x_1}\right)^i\left(\frac{\partial f}{\partial x_2}\right)^j=\frac{\partial^{i+j}f}{\partial x_1^i \partial x_2^j}.$$

We will now give some examples of transvectants.

Ex. gr. if $f=a_x^2$, $\phi=b_x^2$,

$(f,\phi)^{0,0}=a_x^2 b_x^2$

$$(f,\phi)^{1,0}=(ab)a_x b_x=(\bar{a}_0\bar{b}_1-\bar{a}_1\bar{b}_0)x_1^2+(\bar{a}_0\bar{b}_2-\bar{a}_2\bar{b}_0)x_1x_2+(\bar{a}_1\bar{b}_2-\bar{a}_2\bar{b}_1)x_2^2,$$

$$(f,\phi)^{0,1}=a_b a_x b_x=(\bar{a}_0\bar{b}_0+\bar{a}_1\bar{b}_1)x_1^2+(\bar{a}_0\bar{b}_1+\bar{a}_1\bar{b}_0+\bar{a}_1\bar{b}_2+\bar{a}_2\bar{b}_1)x_1x_2+(\bar{a}_1\bar{b}_1+\bar{a}_2\bar{b}_2)x_2^2,$$

$(f,\phi)^{2,0}=(ab)^2=\bar{a}_0\bar{b}_2-2\bar{a}_1\bar{b}_1+\bar{a}_2\bar{b}_0,$

$(f,\phi)^{1,1}=(ab)a_b=\bar{a}_0\bar{b}_1-\bar{a}_1\bar{b}_0+\bar{a}_1\bar{b}_2-\bar{a}_2\bar{b}_1,$

$(f,\phi)^{0,2}=a_b^2=\bar{a}_0\bar{b}_0+2\bar{a}_1\bar{b}_1+\bar{a}_2\bar{b}_2,$

five orthogonal concomitants of two simultaneous quadratics obtained by simple transvection. If a, b be alternative symbols $(f,f')^{1,0}$ and $(f,f')^{1,1}$ vanish identically, and we are left with the quadratic covariant

$(f,f')^{0,1}=(\bar{a}_0^2+\bar{a}_1^2)x_1^2+2(\bar{a}_0\bar{a}_1+\bar{a}_1\bar{a}_2)x_1x_2+(\bar{a}_1^2+\bar{a}_2^2)x_2^2,$

and the two invariants

$$(f,f')^{2,0}=2(\bar{a}_0\bar{a}_2-\bar{a}_1^2),\ (f,f')^{0,2}=\bar{a}_0^2+2\bar{a}_1^2+\bar{a}_2^2.$$

We may proceed by transvection from the forms $(xa)a_x$ and $(xa)^2$. Observe that

$$(xa)a_x=\bar{a}_1x_1^2-(\bar{a}_0-\bar{a}_2)x_1x_2-\bar{a}_1x_2^2,$$
$$(xa)^2=\bar{a}_2x_1^2-2\bar{a}_1x_1x_2+\bar{a}_0x_2^2;$$

thus

$$\left\{(xa)^2,b_x^2\right\}^{1,0}=a_b(xa)b_x$$
$$=(\bar{a}_1\bar{b}_0+\bar{a}_2\bar{b}_1)x_1^2-(\bar{a}_0\bar{b}_0-\bar{a}_2\bar{b}_2)x_1x_2-(\bar{a}_0\bar{b}_1+\bar{a}_1\bar{b}_2)x_2^2;$$
$$\left\{(xa)^2,b_x^2\right\}^{0,1}=-(ab)(xa)b_x$$
$$=-\left\{(\bar{a}_1\bar{b}_1-\bar{a}_2\bar{b}_0)x_1^2+(-\bar{a}_0\bar{b}_1+\bar{a}_1\bar{b}_0+\bar{a}_1\bar{b}_2-\bar{a}_2\bar{b}_1)x_1x_2+(\bar{a}_1\bar{b}_1-\bar{a}_0\bar{b}_2)x_2^2\right\};$$
$$\left\{(xa)^2,(xb)^2\right\}^{1,0}=(ab)(xa)(xb)$$
$$=(\bar{a}_1\bar{b}_2-\bar{a}_2\bar{b}_1)x_1^2-(\bar{a}_0\bar{b}_2-\bar{a}_2\bar{b}_0)x_1x_2+(\bar{a}_0\bar{b}_1-\bar{a}_1\bar{b}_0)x_2^2;$$

where observe that this form is obtained from $(ab)a_xb_x$ by writing $-x_2$, x_1 in place of x_1, x_2, a process which is always invariant. From one covariant we can in this way always derive another of the same degree-order. To see how this is take the linear operator

$$x_1\frac{\partial}{\partial x_2}-x_2\frac{\partial}{\partial x_1}=\left(x\frac{\partial}{\partial x}\right),$$

and further the operator of order k

$$\left(x_1\frac{\partial}{\partial x_2}-x_2\frac{\partial}{\partial x_1}\right)^k=\left(x\frac{\partial}{\partial x}\right)^k,$$

obtained by symbolic expansion.

Then

$$\left(x\frac{\partial}{\partial x}\right)a_x^n=\frac{n!}{(n-k)!}(xa)^k a_x^{n-k},$$
$$\left(x\frac{\partial}{\partial x}\right)^k(xa)^n=(-)^k\frac{n!}{(n-k)!}(xa)^{n-k}a_x^k;$$

so that

$$\frac{1}{n!}\left(x\frac{\partial}{\partial x}\right)^n a_x^n=(xa)^n,$$
$$\frac{(-)^n}{n!}\left(x\frac{\partial}{\partial x}\right)^n(xa)^n=a_x^n,$$

and

$$\frac{(-)^n}{(n!)^2}\left(x\frac{\partial}{\partial x}\right)^n\left(x\frac{\partial}{\partial x}\right)^n a_x^n=a_x^n.$$

Hence the operation of writing $-x_2$, x_1 in place of x_1, x_2 in any form a_x^n or $(xa)^n$ is, disregarding a numerical factor, equal to the performance of $\left(x\frac{\partial}{\partial x}\right)^n$, an operation of order n. Hence, when this operation is performed upon any symbolic product

$$(xa)^p(xb)^q\ldots a_x^s b_x^t\ldots$$

of order n in x, it effectively produces

$$a_x^p b_x^q\ldots(xa)^s(xb)^t\ldots$$

The operations

$$\left(x\frac{\partial}{\partial x}\right),\left(x\frac{\partial}{\partial x}\right)^2\ldots\left(x\frac{\partial}{\partial x}\right)^n,$$

when performed upon a_x^n or $(xa)^n$ produce the $n+1$ covariants, of order n,

$$a_x^n,(xa)a_x^{n-1},(xa)^2a_x^{n-2},\ldots(xa)^n;$$

which we may conceive to be generated by the expansion of $\{a_x+\lambda(xa)\}^n$; that is to say, by giving, in a_x^n, a_1, a_2 the increments $+\lambda a_2$, $-\lambda a_1$, respectively. We have a relation connecting any two quasi-adjacent covariants of the series, for since

$$a_x^2+(xa)^2=a_ax_x,$$
$$(xa)^{\rho-2}a_x^{n-\rho+2}+(xa)^\rho a_x^{n-\rho}=a_a(xa)^{\rho-2}a_x^{n-\rho}x_x;$$

which shows that the sum of every two quasi-adjacent covariants contains the factor a_ax_x. The identity obtains whether n be the order of the original form or no. From it may be derived others of the kind

$$(xa)^{\rho-2}a_x^{n-\rho+2}+2(xa)^\rho a_x^{n-\rho}+(xa)^{\rho+2}a_x^{n-\rho-2}$$
$$=a_a^2(xa)^{\rho-2}a_x^{n-\rho-2}x_x^2.$$

These relations indicate that these covariants do not constitute a fundamentally irreducible set of covariants; for the covariant $a_a(xa)^{\rho-2}a_x^{n-\rho}x_x$, is the product of $a_a(xa)^{\rho-2}a_x^{n-\rho}$, x_x each of which is a covariant; and similarly $a_a^2(xa)^{\rho-2}a_x^{n-\rho-2}x_x^2$ is the product of $a_a^2(xa)^{\rho-2}a_x^{n-\rho-2}$ and x_x^2, each of which is a covariant. Between the $n+1$ covariants we can establish $n-1$ independent relations giving $n-1$ reductions; the system is therefore reduced to two forms which we may take to be a_x^n and $(xa)a_x^{n-1}$. So also, in regard to any covariant ϕ_x^p, we need only consider the further form $(x\phi)\phi_x^{p-1}$.

A process, somewhat similar to transvection, may like $\left(x\frac{\partial}{\partial x}\right)$ be performed upon a single form; this is

$$\frac{\partial^2}{\partial x_1^2}+\frac{\partial^2}{\partial x_2^2}=\frac{\partial}{\partial x}_{\frac{\partial}{\partial x}}$$

in analogy with the notation $x_1^2+x_2^2=x_x$.

We have

$$\frac{1}{2!}\left(\frac{\partial^2}{\partial x_1^2}+\frac{\partial^2}{\partial x_2^2}\right)a_x^n=\binom{n}{2}a_aa_x^{n-2},$$

a covariant of degree-order $1, n-2$.

While, in general,

$$\left(\frac{\partial^2}{\partial x_1^2}+\frac{\partial^2}{\partial x_2^2}\right)^k a_x^n \quad =\frac{n!}{(n-2k)!}a_a^k a_x^{n-2k},$$

$$\left(\frac{\partial^2}{\partial x_1^2}+\frac{\partial^2}{\partial x_2^2}\right)^k (xa)^n=\frac{n!}{(n-2k)!}a_a^k (xa)^{n-2k}.$$

To these results it is useful to add

$$\left(\frac{\partial^2}{\partial x_1^2}+\frac{\partial^2}{\partial x_2^2}\right)^k a_x^{n-1}(xa)=\frac{(n-1)!}{(n-2k-1)!}a_a^k a_x^{n-2k-1}(xa).$$

Ex. gr. from the quadratic a_x^2 we derive

$$a_a=a_1^2+a_2^2=\bar{a}_0+\bar{a}_2,$$

from the cubic a_x^3 the linear covariant

$$a_a a_x=(\bar{a}_0+\bar{a}_2)x_1+(\bar{a}_1+\bar{a}_3)x_2,$$

and from the cubic covariant $a_x^2(xa)$ of the cubic

$$a_a(xa)=(\bar{a}_1+\bar{a}_3)x_1-(\bar{a}_0+\bar{a}_2)x_2,$$

a linear covariant otherwise obtainable by operating upon $a_a a_x$ with

$$x_1\frac{\partial}{\partial x_2}-x_2\frac{\partial}{\partial x_1}.$$

Similarly, from the quartic a_x^4, we obtain the quadratic covariant

$$a_a a_x^2=(\bar{a}_0+\bar{a}_2)x_1^2+2(\bar{a}_1+\bar{a}_3)x_1x_2+(\bar{a}_2+\bar{a}_4)x_2^2,$$

and the invariant

$$a_a^2=\bar{a}_0+2\bar{a}_2+\bar{a}_4.$$

It has been shown, by Sylvester, that all orthogonal covariants satisfy the partial differential equation

$$a_0\frac{\partial}{\partial a_1}+2a_1\frac{\partial}{\partial a_2}+\dots+na_{n-1}\frac{\partial}{\partial a_n}$$
$$-\left\{na_1\frac{\partial}{\partial a_0}+(n-1)a_2\frac{\partial}{\partial a_1}+\dots+a_n\frac{\partial}{\partial a_{n-1}}\right\}+x_1\frac{\partial}{\partial x_2}-x_2\frac{\partial}{\partial x_1}=0,$$

which, in the notation employed in a previous page, is

$$\Omega_a-O_a+\left(x\frac{\partial}{\partial x}\right)=0.$$

If then a covariant, of order ϵ to an n^{ic}, be

$$\Sigma C_k x_1^{\epsilon-k}x_2^k,$$

the operation produces

$$\sum_k\left\{x_1^{\epsilon-k}x_2^k(\Omega_a-O_a)C_k+C_k k x_1^{\epsilon-k+1}x_2^{k-1}-C_k(\epsilon-k)x_1^{\epsilon-k-1}x_2^{k+1}\right\},$$

the vanishing of which necessitates the relations which, writing $O_a-\Omega_a=V$, take the form

$$\begin{array}{rcrl} C_1 & - & VC_0 & =0,\\ 2C_2-VC_1 & - & \epsilon C_0 & =0,\\ 3C_3-VC_2 & - & (\epsilon-1)C_1 & =0,\\ \cdot\quad\cdot & \cdot & \cdot\quad\cdot & \\ \epsilon C_\epsilon-VC_{\epsilon-1} & - & 2C_{\epsilon-2} & =0; \end{array}$$

and thence

$$\begin{aligned} C_1&=VC_0,\\ 2C_2&=\{(V^2+1)+(\epsilon-1)\}C_0,\\ 3!C_3&=\{V(V^2+4)+3(\epsilon-2)V\}C_0,\\ 4!C_4&=\{(V^2+1)(V^2+9)+6(\epsilon-3)(V^2+1)+3(\epsilon-1)(\epsilon-3)\}C_0,\\ 5!C_5&=\{V(V^2+4)(V^2+16)+10(\epsilon-4)V(V^2+4)\\ &\qquad+15(\epsilon-2)(\epsilon-4)\}C_0;\\ &\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot \end{aligned}$$

indicating the manner of obtaining the successive covariant coefficients when once the leading coefficient C_0 is known.

Ex. gr. Taking as leading coefficient a_0^2, the order of the covariant is $2n-4$, and the three first terms

$$\begin{aligned} &(a_0^2+2\bar{a}_1^2+\bar{a}_2^2)x_1^{2n-4}\\ &+2(n-2)(\bar{a}_0\bar{a}_1+2\bar{a}_1\bar{a}_2+\bar{a}_2\bar{a}_3)x_1^{2n-5}x_2\\ &+(n-2)\left\{(n-2)(\bar{a}_1^2+2\bar{a}_2^2+\bar{a}_3^2)+(n-3)(\bar{a}_0\bar{a}_2+2\bar{a}_1\bar{a}_3+\bar{a}_2\bar{a}_4)\right\}\\ &\qquad\qquad\times x_1^{2n-6}x_2^2\\ &+\dots. \end{aligned}$$

It may be gathered, from the above relations, that, for covariants of orders 0, 1, 2, 3, 4,..., the leading coefficients C_0 satisfy the equations

$$\begin{aligned} VC_0&=0,\\ (V^2+1)C_0&=0,\\ V(V^2+4)C_0&=0,\\ (V^2+1)(V^2+9)C_0&=0,\\ V(V^2+4)(V^2+16)C_0&=0,\\ \cdot\quad\cdot\quad\cdot&\quad\cdot\quad\cdot \end{aligned}$$

respectively. It is thus important to notice that for each order of covariant we have a special differential equation. We can infer from the annihilating operator $V(V^2+4)$ for covariants of the second order that the function $(V^2+4)C_0$ is an invariant of the same binary form.

Ex. gr. For the binary quadratic a_x^2, a_0 is the leading coefficient of the form itself, a covariant of the second order, and as a consequence the operation

$$\left(2a_1\frac{\partial}{\partial a_0}+a_2\frac{\partial}{\partial a_1}-a_0\frac{\partial}{\partial a_1}-2a_1\frac{\partial}{\partial a_2}\right)^2+4$$

when performed upon a_0 must produce an invariant; it, in fact, produces the invariant

$$2(\bar{a}_0+\bar{a}_2).$$

The annihilator, in respect of a covariant of order $2s$, is

$$V(V^2+2^2)(V^2+4^2)\dots(V^2+4s^2);$$

and if the order be $2s+1$

$$(V^2+1^2)(V^2+3^2)\dots(V^2+4s^2+4s+1);$$

so that, in general, the operation $V^2+\epsilon^2$ upon a leading coefficient of a covariant of order ϵ produces a leader of a covariant of order $\epsilon-2$ appertaining to the same binary form, and this must necessarily be of the same degree in the coefficients.

Ex. gr. From the Hessian of the cubic a_x^3, viz., $(ab)^2a_xb_x$, we thus obtain the invariant

$$\bar{a}_0\bar{a}_2-\bar{a}_1^2+\bar{a}_1\bar{a}_3-\bar{a}_2^2=a_b(ab)^2.$$

It will be noticed that a source of a linear covariant is annihilated by V^2+1.

The Boolian System.—The form is $a_x^n=(a_1x_1+a_2x_2)^n$, associated with the quadratic $x_1^2+2\cos\omega x_1x_2+x_2^2$. a_x^n is transformed to $A_x^n=(A_1x_1+A_2x_2)^n$, by the substitutions

$$x_1=\frac{\sin(\omega-\alpha)}{\sin\omega}X_1+\frac{\sin(\omega-\beta)}{\sin\omega}X_2,$$

$$x_2=\qquad\frac{\sin\alpha}{\sin\omega}X_1+\qquad\frac{\sin\beta}{\sin\omega}X_2,$$

of modulus $\dfrac{\sin\omega'}{\sin\omega}$; where $\omega'=\beta-\alpha$.

The problem is to find functions of the original coefficients, variables, and ω, which by the transformation become the like functions of the new coefficients and variables and ω', save as to a power of the modulus. a_a and (ab) clearly possess the invariant property.

Put
$$\begin{aligned} a_1-a_2\cos\omega&=b_1-b_2\cos\omega=\dots=\alpha_1=\beta_1=\dots,\\ a_2-a_1\cos\omega&=b_2-b_1\cos\omega=\dots=\alpha_2=\beta_2=\dots\\ x_1+x_2\cos\omega&=\xi_1,\\ x_2+x_1\cos\omega&=\xi_2, \end{aligned}$$

where α_1, α_2; β_1, β_2,... are new umbræ and ξ_1, ξ_2 are auxiliary variables.

Let the transformation convert α_1, α_2 into $\mathbf{A}_1$, $\mathbf{A}_2$, where

$$\mathbf{A}_1=A_1-A_2\cos\omega',$$
$$\mathbf{A}_2=A_2-A_1\cos\omega',$$

and ξ_1, ξ_2 into Ξ_1, Ξ_2, where

$$\Xi_1=X_1+X_2\cos\omega'=\cos\alpha\, x_1+\cos(\omega-\alpha)x_2,$$
$$\Xi_2=X_2+X_1\cos\omega'.=\cos\beta\, x_1+\cos(\omega-\beta)x_2.$$

Observe that

$$x_\xi=x_1\xi_1+x_2\xi_2=x_1^2+2\cos\omega x_1x_2+x_2^2.$$

Now

$$X_1=\frac{\sin\beta}{\sin\omega'}x_1-\frac{\sin(\omega-\beta)}{\sin\omega'}x_2,$$

$$X_2=-\frac{\sin\alpha}{\sin\omega'}x_1+\frac{\sin(\omega-\alpha)}{\sin\omega'}x_2,$$

$$A_1=\frac{\sin(\omega-\alpha)}{\sin\omega}a_1+\frac{\sin\alpha}{\sin\omega}a_2,$$

$$A_2=\frac{\sin(\omega-\beta)}{\sin\omega}a_1+\frac{\sin\beta}{\sin\omega}a_2,$$

$$\mathbf{A}_1=\frac{\sin\omega'}{\sin\omega}\quad\{\cos(\omega-\beta)\alpha_1-\cos\beta\alpha_2\},$$

$$\mathbf{A}_2=\frac{\sin\omega'}{\sin\omega}\{-\cos(\omega-\alpha)\alpha_1+\cos\alpha\alpha_2\};$$

whence it can be shown that

$$(X\mathbf{A})=X_1\mathbf{A}_2-X_2\mathbf{A}_1=X_1(A_2-A_1\cos\omega')-X_2(A_1-A_2\cos\omega')$$
$$=\frac{\sin\omega}{\sin\omega}(x\alpha);$$

from which we learn that $(x\alpha)$ possesses the invariant property. Further, it may be verified that

$$A_{\mathbf{A}}=\left(\frac{\sin\omega'}{\sin\omega}\right)^2\alpha_\alpha;\ A_{\mathbf{B}}=\left(\frac{\sin\omega'}{\sin\omega}\right)^2\alpha_\beta;$$

so that a_α, a_β possess, each of them, the invariant property. There are thus six invariant symbolic factors, viz., (ab), a_α, a_β, $(x\alpha)$, a_x, x_ξ; and from these types we are able to form invariant symbolic products. We must note the results—

$$(\xi a)=(x\alpha)\,;\ \alpha_\xi=\sin^2\omega a_x\,;\ (\alpha\beta)=\sin^2\omega(ab)$$

$$(x\xi)=\cos\omega(x_1^2-x_2^2)\,;\ (a\alpha)=\cos\omega(a_1^2-a_2^2).$$

Since $\sin^2\omega$ is the discriminant of x_ξ we may regard a_ξ and $(\alpha\beta)$ as reducible, and we take as the general form of invariant—

$$(ab)^{k_1}(ac)^{k_2}(bc)^{k_3}\ldots a_\alpha^{l_1}b_\beta^{l_2}c_\gamma^{l_3}\ldots a_\beta^{j_1}a_\gamma^{j_2}b_\gamma^{j_3}\ldots$$
$$\times(x\alpha)^{h_1}(x\beta)^{h_2}(x\gamma)^{h_3}\ldots a_x^{i_1}b_x^{i_2}c_x^{i_3}\ldots x_\xi^m,$$

which should be contrasted with the corresponding expression for orthogonal invariants.

If this be of order ϵ and appertain to an a^{ic}

$$\Sigma k+\Sigma l+2m=\epsilon,$$

the pair of symbols a, α must together appear n times; so also for b, β; c, γ; …

We have the symbolic identities

$$b_\alpha=a_\beta,\ y_\xi=x_\eta\,;$$
$$a_\alpha b_\beta-a_\beta b_\alpha=(\alpha\beta)(ab)=\sin^2\omega(ab)^2\,;$$
$$a_\alpha x_\xi-(x\alpha)^2=a_x a_\xi=\sin^2\omega\, a_x^2\,;$$
$$(ab)c_\alpha+(bc)a_\alpha+(ca)b_\alpha=0\,;$$

and many others, derivable from these, which are of assistance in the reduction of symbolic products. We may give here some simple examples of Boolian invariants.

Ex. gr. For the linear form $a_x=b_x=\ldots$, we have

(i.) $a_x=\bar{a}_0x_1+\bar{a}_1x_2$,

(ii.) $x_\xi=x_1^2+2\cos\omega\, x_1x_2+x_2^2$,

(iii.) $\sin^2\omega$,

(iv.) $(x\alpha)=(\bar{a}_1-\bar{a}_0\cos\omega)x_1-(a_0-a_1\cos\omega)x_2$,

(v.) $a_\beta=\bar{a}_0^2-2\bar{a}_0\bar{a}_1\cos\omega+\bar{a}_1^2$.

For two linear forms (v.) yields the simultaneous invariant

$$\bar{a}_0\bar{b}_0+\bar{a}_1\bar{b}_1-\cos\omega(\bar{a}_0\bar{b}_1+\bar{a}_1\bar{b}_0).$$

For the quadratic form $a_x^2=b_x^2=\ldots$, we have the system

(i.) a_x^2,

(ii.) x_ξ,

(iii.) $\sin^2\omega$,

(iv.) $\frac{1}{2}(ab)^2=\bar{a}_0\bar{a}_2-\bar{a}_1^2$,

(v.) $(x\alpha)a_x=(\bar{a}_1-\bar{a}_0\cos\omega)x_1^2+(\bar{a}_2-\bar{a}_0)x_1x_2+(\bar{a}_2\cos\omega-\bar{a}_1)x_2^2$,

which is the Jacobian of a_x^2 and x_ξ;

(vi.) $a_\alpha=\bar{a}_0-2\cos\omega\,\bar{a}_1+\bar{a}_2$;

and it may be shown that all other covariants are rational integral functions of these six forms.

Again, take the quadratic $a_x^2=b_x^2=\ldots$ and the linear form $a'_x=b'_x=\ldots$; besides the forms, appertaining to the linear form and quadratic separately, which have been already given, we have four additional forms involving the coefficients of both forms, viz.:—

$$(aa')(ab')=\bar{a}_0\bar{a}_1'^2-2\bar{a}_1\bar{a}_0'\bar{a}_1'+\bar{a}_2\bar{a}_0'^2,$$

$$a'_\alpha(aa')=(a_1-a_0\cos\omega)\bar{a}_1'^2+(\bar{a}_0-\bar{a}_2)\bar{a}_0'\bar{a}_1'+(\bar{a}_2\cos\omega-\bar{a}_1)\bar{a}_0'^2,$$

$$(aa')a_x=(\bar{a}_0\bar{a}_1'-\bar{a}_1\bar{a}_0')_1x+(\bar{a}_1\bar{a}_1'-\bar{a}_2\bar{a}_0')x_2,$$

$$(x\alpha)(aa')=\left\{\bar{a}_1\bar{a}_1'-\bar{a}_2\bar{a}_0'-\cos\omega\left(\bar{a}_0\bar{a}_1'-\bar{a}_1\bar{a}_0'\right)\right\}x_1$$
$$-\left\{\bar{a}_0\bar{a}_1'-\bar{a}_1\bar{a}_0'-\cos\omega\left(\bar{a}_1\bar{a}_1'-\bar{a}_2\bar{a}_0'\right)\right\}x_2.$$

(See Elliott, *loc. cit.* p. 366).

The polar processes must now be examined. We have, η_1, η_2, being cogredient with ξ_1, ξ_2,

$$\frac{(m-k)!}{m!}\left(y_1\frac{\partial}{\partial x_1}+y_2\frac{\partial}{\partial x_2}\right)^k a_x^m=a_x^{m-k}a_y^k,$$
$$\frac{(m-k)!}{m!}\left(y_1\frac{\partial}{\partial x_1}+y_2\frac{\partial}{\partial x_2}\right)^k(x\alpha)^m=(x\alpha)^{m-k}(y\alpha)^k,$$
$$\frac{(m-k)!}{m!}\left(\eta_1\frac{\partial}{\partial\xi_1}+\eta_2\frac{\partial}{\partial\xi_2}\right)^k a_x^m=a_x^{m-k}a_y^k,$$
$$\frac{(m-k)!}{m!}\left(\eta_1\frac{\partial}{\partial\xi_1}+\eta_2\frac{\partial}{\partial\xi_2}\right)^k(x\alpha)^m=(x\alpha)^{m-k}(y\alpha)^k,$$
$$\frac{(m-k)!}{m!}\left\{\sin^2\omega\left(y_1\frac{\partial}{\partial\xi_2}-y_2\frac{\partial}{\partial\xi_1}\right)\right\}^k a_x^m=a_x^{m-k}(y\alpha)^k,$$
$$\frac{(m-k)!}{m!}\left(y_1\frac{\partial}{\partial\xi_2}-y_2\frac{\partial}{\partial\xi_1}\right)^k(\alpha x)^m=(\alpha x)^{m-k}a_y^k,$$
$$\frac{(m-k)!}{m!}\left(\eta_1\frac{\partial}{\partial x_2}-\eta_2\frac{\partial}{\partial x_1}\right)^k a_x^m=a_x^{m-k}(y\alpha)^k,$$
$$\frac{(m-k)!}{m!}\left\{\sin^2\omega\left(\eta_1\frac{\partial}{\partial x_2}-\eta_2\frac{\partial}{\partial x_1}\right)\right\}^k(\alpha x)^m=(\alpha x)^{m-k}a_y^k\,;$$

from which it appears that, as regards a_x^m, we need only consider the operations

$$y_1\frac{\partial}{\partial x_1}+y_2\frac{\partial}{\partial x_2}\ \text{and}\ \eta_1\frac{\partial}{\partial x_2}-\eta_2\frac{\partial}{\partial x_1}\,;$$

and, as regards $(x\alpha)^m$, only

$$y_1\frac{\partial}{\partial x_1}+y_2\frac{\partial}{\partial x_2}\ \text{and}\ y_1\frac{\partial}{\partial\xi_2}-y_2\frac{\partial}{\partial\xi_1}\,;$$

and we have the processes

$$\frac{(m-k_1-k_2)!}{m!}\left(y_1\frac{\partial}{\partial x_1}+y_2\frac{\partial}{\partial x_2}\right)^{k_1}\left(\eta_1\frac{\partial}{\partial x_2}-\eta_2\frac{\partial}{\partial x_1}\right)^{k_2}a_x^m$$
$$=a_x^{m-k_1-k_2}a_y^{k_1}(y\alpha)^{k_2}\,;$$
$$\frac{(m-k_1-k_2)!}{m!}\left(y_1\frac{\partial}{\partial x_1}+y_2\frac{\partial}{\partial x_2}\right)^{k_1}\left(y_1\frac{\partial}{\partial\xi_2}-y_2\frac{\partial}{\partial\xi_1}\right)^{k_2}(\alpha x)^m$$
$$=(\alpha x)^{m-k_1-k_2}(\alpha y)^{k_1}a_y^{k_2}.$$

The two forms $a_x^{m-k}a_y^k$, $(x\alpha)^{m-k}(y\alpha)^k$, satisfy the partial differential equation

$$\frac{\partial^2u_1}{\partial x_1\partial y_2}-\frac{\partial^2u_1}{\partial x_2\partial y_1}=0\,;$$

and the two forms $a_x^{m-k}(y\alpha)^k$, $(x\alpha)^{m-k}a_y^k$, the partial differential equation

$$\frac{\partial^2u_2}{\partial x_1\partial\eta_1}+\frac{\partial^2u_2}{\partial x_2\partial\eta_2}=0\,;$$

to verify this statement recall that

$$(y\alpha)=(\eta a),\ a_\eta=\sin^2\omega\, a_y.$$

Taking, as operand, any form $a_x^{m-k}b_y^k$ we write

$$\Omega=\frac{1}{(m-k)k}\left(\frac{\partial^2}{\partial x_1\partial y_2}-\frac{\partial^2}{\partial x_2\partial y_1}\right),$$
$$\text{O}_{x,\eta}=\frac{1}{(m-k)k}\left(\frac{\partial^2}{\partial x_1\partial\eta_1}+\frac{\partial^2}{\partial x_2\partial\eta_2}\right),$$

and we can establish the relations

$$\Omega^{k_1}(\text{O}_{x\eta}\sin^2\omega)^{k_2}a_x^m b_y^n=(ab)^{k_1}a_\beta^{k_2}a_x^{m-k_1-k_2}b_y^{n-k_1-k_2},$$
$$\Omega^{k_1}\text{O}_{x\eta}^{k_2}a_x^m(y\beta)^n=(-)^{k_1}(ab)^{k_2}a_\beta^{k_1}a_x^{m-k_1-k_2}(y\beta)^{n-k_1-k_2},$$
$$\Omega^{k_1}\text{O}_{x\eta}^{k_2}(x\alpha)^m b_y^n=(-)^{k_2}(ab)^{k_2}a_\beta^{k_1}(x\alpha)^{m-k_1-k_2}b_y^{n-k_1-k_2},$$
$$(\Omega\operatorname{cosec}^2\omega)^{k_1}\text{O}_{x\eta}^{k_2}(x\alpha)^m(y\beta)^n=(ab)^{k_1}a_\beta^{k_2}(x\alpha)^{m-k_1-k_2}(y\beta)^{n-k_1-k_2}.$$

From these relations, by putting $y=x$, we derive the processes of transvection, and we may write

$$(a_x^m,b_x^m)^{k_1,k_2}=(ab)^{k_1}a_\beta^{k_2}a_x^{m-k_1-k_2}b_x^{n-k_1-k_2},$$
$$\left\{a_x^m,(x\beta)^n\right\}^{k_1,k_2}=a_\beta^{k_1}(ab)^{k_2}a_x^{m-k_1-k_2}b_x^{n-k_1-k_2},$$
$$\left\{(x\alpha)^m,b_x^n\right\}^{k_1,k_2}=a_\beta^{k_1}(ab)^{k_2}(x\alpha)^{m-k_1-k_2}b_x^{n-k_1-k_2},$$
$$\left\{(x\alpha)^m,(x\beta)^n\right\}^{k_1,k_2}=(ab)^{k_1}a_\beta^{k_2}(x\alpha)^{m-k_1-k_2}(x\beta)^{n-k_1-k_2}.$$

Of order $k=k_1+k_2$ there are $k+1$ transvectants, and k may have any value not greater than the least of the numbers m, n.

The process is practically equivalent to the performance of the differential operation

$$\left(\frac{\partial f}{\partial x_1}\frac{\partial\phi}{\partial x_2}-\frac{\partial f}{\partial x_2}\frac{\partial\phi}{\partial x_1}\right)^{k_1}\left(\frac{\partial f}{\partial x_1}\frac{\partial\phi}{\partial\xi_1}+\frac{\partial f}{\partial x_2}\frac{\partial\phi}{\partial\xi_2}\right)^{k_2},$$

the multiplication of operators being symbolic. We have next to consider the operation

$$\left(x\frac{\partial}{\partial\xi}\right)=x_1\frac{\partial}{\partial\xi_2}-x_2\frac{\partial}{\partial\xi_1},\text{ upon } a_x^m=(\sin^2\omega)^{-m}a_\xi^m;\text{ we find}$$

$$\left(x_1\frac{\partial}{\partial\xi_2}-x_2\frac{\partial}{\partial\xi_1}\right)a_x^m=m(\sin^2\omega)^{-m}a_\xi^{m-1}(x\alpha)=\frac{m}{\sin^2\omega}a_x^{m-1}(x\alpha);$$

∴ Calling the operation

$$\frac{1}{m}\sin^2\omega\left(x_1\frac{\partial}{\partial\xi_2}-x_2\frac{\partial}{\partial\xi_1}\right),$$

when performed upon a_x^m, P, we have $\mathrm{P}^k a_x^m=(x\alpha)^k a_x^{m-k}$;

P^k is, in fact, $\dfrac{(m-k)!}{m!}\sin^{2k}\omega\left(x_1\dfrac{\partial}{\partial\xi_2}-x_2\dfrac{\partial}{\partial\xi_1}\right)^k$,

the operator being expanded symbolically. Similarly

$$(-)^k\frac{(m-k)!}{m!}\left(x\frac{\partial}{\partial\xi}\right)^k(x\alpha)^m=(x\alpha)^{m-k}a_x^k.$$

Hence

$$\left(x\frac{\partial}{\partial\xi}\right)^m$$

has the effect, practically, of converting a_x^m into $(x\alpha)^m$; this can be otherwise accomplished by writing $-x_2, x_1$ in place of x_1, x_2, and changing a into α. $(x\alpha)^m$ is similarly converted into a_x^m, only here α is changed into a. If the operand be $a_x^{m-k}(x\alpha)^k$ it becomes converted by the operation into $(x\alpha)^{m-k}a_x^k$. The covariants of the series $(x\alpha)^k a_x^{m-k}$ are all reducible except a_x^m and $(x\alpha)a_x^{m-1}$, as may be seen from the identities

$$\begin{aligned}&\sin^2\omega(x\alpha)^k a_x^{m-k}+(x\alpha)^{k+2}a_x^{m-k-2}\\&=(x\alpha)^k a_x^{m-k-2}\left\{\sin^2\omega a_x^2+(x\alpha)^2\right\}\\&=a_\alpha(x\alpha)^k a_x^{m-k-2}x_\xi;\end{aligned}$$

which exhibits the reduction of $(x\alpha)^{k+2}a_x^{m-k-2}$. Next consider the operation of

$$\frac{\partial^2}{\partial x_1\partial\xi_1}+\frac{\partial^2}{\partial x_2\partial\xi_2},$$

upon a_x^m and $(x\alpha)^m$. We find

$$\sin^{2k}\omega\left(\frac{\partial^2}{\partial x_1\partial\xi_1}+\frac{\partial^2}{\partial x_2\partial\xi_2}\right)^k a_x^m=\frac{m!}{(m-2k)!}a_\alpha^k a_x^{m-2k},$$

$$\left(\frac{\partial^2}{\partial x_1\partial\xi_1}+\frac{\partial^2}{\partial x_2\partial\xi_2}\right)^k(x\alpha)^m=\frac{m!}{(m-2k)!}a_\alpha^k(x\alpha)^{m-2k},$$

$$\sin^{2k}\omega\left(\frac{\partial^2}{\partial x_1\partial\xi_1}+\frac{\partial^2}{\partial x_2\partial\xi_2}\right)^k a_x^{m-1}(x\alpha)=\frac{(m-1)!}{(m-2k-1)!}a_\alpha^k a_x^{m-2k-1}(x\alpha).$$

Before proceeding to give examples of these processes it must be observed that the transvectant

$$\left(a_x^m, b_x^n\right)^{0,k_2}$$

is always reducible where k_2 is even. This arises from the symbolic identity

$$\sin^2\omega(ab)^2+a_\beta^2=a_\alpha b_\beta;$$

for, thence,

$$\left(a_x^m, b_x^n\right)^{0,2}+\sin^2\omega\left(a_x^m, b_x^n\right)^{2,0}=\left(a_\alpha a_x^{m-2}\right)\left(b_\beta b_x^{n-2}\right),$$

$$\begin{aligned}&\left(a_x^m, b_x^n\right)^{0,4}+2\sin^2\omega\left(a_x^m, b_x^n\right)^{2,2}+\sin^4\omega\left(a_x^m, b_x^n\right)^{4,0}\\&=\left(a_\alpha^2 a_x^{m-4}\right)\left(b_\beta^2 b_x^{n-4}\right),\end{aligned}$$

with similar identities which establish the theorem.

Ex. gr. Consider transvectants of a_x^3 over b_x^3

$\left(a_x^3, b_x^3\right)^{1,0}=(ab)a_x^2 b_x^2$,

$\left(a_x^3, b_x^3\right)^{0,1}=a_\beta a_x^2 b_x^2$; which, for the single cubic a_x^3 gives

$$\begin{aligned}&(a^2-2ab\cos\omega+b^2)x^4+4\{ab-(ac+b^2)\cos\omega+bc\}x^3y\\&+2\{ac+2b^2-(ad+5bc)\cos\omega+bd+2c^2\}x^2y^2\\&+4\{bc-(bd+c^2)\cos\omega+cd\}xy^3\\&+(c^2-2cd\cos\omega+d^2)y^4,\end{aligned}$$

which is unchanged when a, b, c, d, x, y are changed into d, c, b, a, y, x respectively.

$\left(a_x^3, b_x^3\right)^{2,0}=(ab)^2 a_x b_x$,

$\left(a_x^3, b_x^3\right)^{1,1}=(ab)a_\beta a_x b_x$, which vanishes for the single cubic,

$\left(a_x^3, b_x^3\right)^{3,0}=(ab)^3$,

$\left(a_x^3, b_x^3\right)^{2,1}=(ab)^2 a_\beta$; which for a single cubic, is

$$2\{(ac-b^2)-(ad-bc)\cos\omega+(bd-c^2)\}.$$

$\left(a_x^3, b_x^3\right)^{1,2}=(ab)a_\beta^2$; which vanishes for a single cubic, but, for two cubics, is

$$\begin{aligned}&ab'-ba'+2(bc'-cb')+(cd'-dc')\\&-2(ac'-ca'+bd'-db')\cos\omega\\&+(ad'-da'+bc'-cb')\cos^2\omega.\end{aligned}$$

$\left(a_x^3, b_x^3\right)^{0,3}=a_\beta^3$ which, for a single cubic, is

$$\begin{aligned}&a^2+3b^2+3c^2+d^2-6(ab+2bc+cd)\cos\omega\\&+6(ac+b^2+bd+c^2)\cos^2\omega-2(ad+3bc)\cos^3\omega.\end{aligned}$$

Again the linear covariant $a_\alpha a_x$ is

$$(a-2b\cos\omega+c)x+(b-2c\cos\omega+d)y;$$

and the linear covariant $a_\alpha(x\alpha)$ is

$$\begin{aligned}&\{b+d-(a+3c)\cos\omega+2b\cos^2\omega\}x\\-&\{a+c-(3b+d)\cos\omega+2c\cos^2\omega\}y.\end{aligned}$$

An invariant of the cubic which is of the fourth degree in the coefficients is

$$a_\beta^2 c_\delta^2 a_\gamma b_\delta$$

which is derived from

$$(ab)^2(cd)^2(ac)(bd)$$

by an obvious method of universal application. Generally, from any covariant given by its symbolic product in the theory of the general linear substitution, we may derive a conjugate form by writing m_ν for (mn) and $(x\mu)$ for m_x, and we are permitted to do this whether or no the former ultimately vanishes; the conjugate cannot vanish. In the general Boolian theory, in any symbolic product, we can pass to a conjugate form by writing

$$m_\nu\text{ for }(mn), (mn)\text{ for }m_\nu, (x\mu)\text{ for }m_x, m_x\text{ for }(x\mu).$$

A form, containing only a_α or x_ξ, will have no conjugate, and may be called a non-conjugate form. Other forms may have vanishing conjugates.

The differential equation, satisfied by Boolian covariants of the binary form a_x^n, has been shown, by Sylvester, to be

$$\cos\omega\left(x_1\frac{\partial}{\partial x_1}-x_2\frac{\partial}{\partial x_2}\right)+\left(x_2\frac{\partial}{\partial x_1}-x_1\frac{\partial}{\partial x_2}\right)+\mathrm{L}=0$$

$$\begin{aligned}\text{where }\mathrm{L}=\mathrm{O}_a-\Omega_a-\cos\omega\Big\{&n\bar{a}_0\frac{\partial}{\partial a_0}+(n-2)\bar{a}_1\frac{\partial}{\partial a_1}\\&+(n-4)\bar{a}_2\frac{\partial}{\partial a_2}+\ldots+(n-2)\bar{a}_{n-1}\frac{\partial}{\partial a_{n-1}}+n\bar{a}_n\frac{\partial}{\partial a_n}\Big\};\end{aligned}$$

If then a covariant be

$$\Sigma\mathrm{C}_k x_1^{\epsilon-k}x_2^k,$$

operation gives

$$\begin{aligned}\Sigma\Big[(\epsilon-2k)\cos\omega\mathrm{C}_k x_1^{\epsilon-k}x_2^k+\mathrm{C}_k\left\{(\epsilon-k)x_1^{\epsilon-k-1}x_2^{k+1}-kx_1^{\epsilon-k+1}x_2^{k-1}\right\}\\+x_1^{\epsilon-k}x_2^k\mathrm{L}.\mathrm{C}_k\Big]=0;\end{aligned}$$

leading to

$$-(k+1)\mathrm{C}_{k+1}+\{\mathrm{L}+(\epsilon-2k)\cos\omega\}\mathrm{C}_k+(\epsilon-k+1)\mathrm{C}_{k-1}=0,$$

and thence to the series of relations

$$\begin{aligned}&-\mathrm{C}_1+(\mathrm{L}+\epsilon\cos\omega)\mathrm{C}_0=0,\\&-2\mathrm{C}_2+\{\mathrm{L}+(\epsilon-2)\cos\omega\}\mathrm{C}_1+\epsilon\mathrm{C}_0=0,\\&-3\mathrm{C}_3+\{\mathrm{L}+(\epsilon-4)\cos\omega\}\mathrm{C}_2+(\epsilon-1)\mathrm{C}_1=0,\\&-4\mathrm{C}_4+\{\mathrm{L}+(\epsilon-6)\cos\omega\}\mathrm{C}_3+(\epsilon-2)\mathrm{C}_2=0,\\&\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\end{aligned}$$

which may be written

$$\begin{aligned}\mathrm{C}_1&=(\mathrm{L}+\epsilon\cos\omega)\mathrm{C}_0,\\2\mathrm{C}_2&=\{\mathrm{L}^2+\sin^2\omega+(\epsilon-1)(\ldots)\}\mathrm{C}_0,\\6\mathrm{C}_3&=\{\mathrm{L}(\mathrm{L}^2+4\sin^2\omega)+(\epsilon-2)(\ldots)\}\mathrm{C}_0\\24\mathrm{C}_4&=\{(\mathrm{L}^2+\sin^2\omega)(\mathrm{L}^2+9\sin^2\omega)+(\epsilon-3)(\ldots)\}\mathrm{C}_0.\\&\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\end{aligned}$$

Hence for leading coefficients of covariants of orders $2s$ and $2s+1$ we have annihilators

$$\mathrm{L}(\mathrm{L}^2+2^2\sin^2\omega)(\mathrm{L}^2+4^2\sin^2\omega)\ldots(\mathrm{L}^2+4s^2\sin^2\omega),$$

$$(\mathrm{L}^2+1^2\sin^2\omega)(\mathrm{L}^2+3^2\sin^2\omega)\ldots\{\mathrm{L}^2+(4s^2+4s+1)\sin^2\omega\}$$

respectively. These conditions are necessary but plainly not sufficient; for every leading coefficient of a covariant, of even order $\ngtr 2s$, satisfies the first operator and, of uneven order $\ngtr 2s+1$, the second operator. We may say, however, that, if the order be $2s$, either

$$(\mathrm{L}^2+4s^2\sin^2\omega)\mathrm{C}_0=0,$$

or else $(\mathrm{L}^2+4s^2\sin^2\omega)\mathrm{C}_0$ is the leading coefficient of a covariant of even order $\ngtr 2s-2$. Similarly, for uneven order $2s+1$, either

$$\{\mathrm{L}^2+(2s+1)^2\sin^2\omega\}\mathrm{C}_0=0,$$

or $\{\mathrm{L}^2+(2s+1)^2\sin^2\omega\}\mathrm{C}_0$, as the leading coefficient of a covariant of uneven order $\ngtr 2s-1$.

Ex. gr. For order 3 of the cubic a_x^3 we find

$$(L^2+9\sin^2\omega)\bar{a}_0=6(\bar{a}_0-2\bar{a}_1\cos\omega+\bar{a}_2),$$

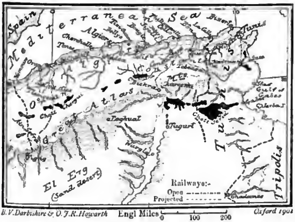
where $\bar{a}_0-2\bar{a}_1\cos\omega+\bar{a}_2$ appertains to the linear covariant $a_a a_x$; and it is easy to verify that $(L^2+\sin^2\omega)a_a a_x=0$.

It is to be remarked that the sources of linear covariants are annihilated by $L^2+\sin^2\omega$. It has been customary for writers to regard the orthogonal and Boolian theories as particular cases of that arising from the general linear substitution. The above sketch will convince the reader that the latter theory is more properly viewed as a particular case of the former theories. Investigations, connected with this section, are a desideratum. No references can be given other than those alluded to, incidentally, in the text.

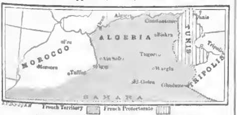
REFERENCES.—CAYLEY. "Memoirs on Quantics" in the *Collected Mathematical Papers.* Cambridge, 1898.—SALMON. *Lessons Introductory to the Modern Higher Algebra.* Dublin, 1885.—E. B. ELLIOTT. *Algebra of Quantics.* Oxford, 1895.—F. BRIÓSCHI. *Teoria dei Covarianti.* Rome, 1861.—W. FIEDLER. *Die Elemente der neueren Geometrie und der Algebra der binären Formen.* Leipzig, 1862.—A. CLEBSCH. *Theorie der binären algebraischen Formen.* Leipzig, 1872. *Vorlesungen über Geometrie.* Leipzig, 1875.—FAÀ DE BRUNO. *Théorie des formes binaries.* Turin, 1876.—P. GORDAN. *Vorlesungen über Invariantentheorie,* Bd. i. "Determinanten," Leipzig, 1885; Bd. ii. *Binäre Formen,* Leipzig, 1887.—G. RUBINI. *Teoria delle forme in generale, e specialmente delle binarie.* Lecce, 1886.—E. STUDY. *Methoden zur Theorie der ternären Formen.* Leipzig, 1889.—LIE. *Theorie der Transformationsgruppen.* Leipzig, 1888-90.—FRANZ MEYER. *Bericht über den gegenwärtigen Stand der Invariantentheorie; Jahresbericht der Deutschen Mathematiker-Vereinigung,* Bd. i. Berlin, 1892.

(P. A. M.)

Algeria, in North Africa, the most important of the colonies of France, lies between Tunis on the east and Morocco on the west, and extends from the Mediterranean to the Sahara. Its area is estimated at 98,500,000 acres, or 153,906 square miles. The principal indentations of the coast are the Gulf of Oran, the Gulf of Arzeu, the Bay of Algiers, the Gulfs of Bougie, Stora, and Bône. The ports are Nemours, Mers el Kebir, Oran, Arzeu, Mostaganem, Tenes, Cherchelle, Algiers, Dellys, Bougie, Jijelli, Collo, Philippeville, Bône, La Calle. Algeria is naturally divided into three parts — the Tell, or coast region, with a breadth varying from 75 to 160 miles; the high plateaus; and the Sahara region. The Tell is traversed by the first chain of the Atlas, consisting in reality of seventeen distinct ranges, among which it is sufficient to mention the Tlemcen range (5500 feet), the Waransenis (6000 feet), the Titéri range (4900 feet), the Jerjéra or Grand Kabyle range (7100 feet), with the peak of Lalla Kedija, and the Babor range (6000 feet). The streams of the Tell are the Tafna (105 miles), the Macta, formed by the Sig and the Habra; the Cheliff (415 miles), the Isser (130 miles), the Sahel (125 miles), the Kebir (140 miles), the Seybouse (145 miles), and the Mejerda, which flows through Tunis to the sea. None of these rivers is navigable. The temperature of the Tell is moderated by the sea-breeze, but the sirocco wind sometimes brings scorching heat. The climate is very healthy, except in the extreme coast region. The high plateaus form a plain of an average height of from 2500 to 3000 feet, dominated by the ridges of the second or Saharan chain of the Atlas, of which the chief points are the Ksour (6000 feet), the Amour and the Aurès (7200 feet). At the foot and to the north of this chain, towards the middle of the plateaus, is a depression containing saline lakes or chotts, of which the best known are the Chergui and the Hodna. The rivers are unimportant; the temperature is variable, passing from one extreme to the other, and rain seldom falls. The Saharan region consists of wide sandy or rocky plains without noteworthy features. The water in general remains under the surface; the temperature is very high by day; rain falls scarcely in one year out of three. Life exists only round the oases or cultivated places. Geologically, the Atlas of the Tell consists of crystalline rocks, schists, and lias. The Tertiary formation hardly ever appears except in its eastern portion. On the other hand, the Little or Saharan Atlas is essentially of Cretaceous and Jurassic formation, like the rocks of the desert itself.



SKETCH MAP OF ALGERIA.



MAP SHOWING THE POLITICAL POSITION OF ALGERIA.

Population.—The population consists of Kabyles or Berbers, Arabs, Moors, Jews, Turks, Coulouglis, Negroes, Mozabides, and Europeans of various nationality. The Berber population is estimated at 75 per cent. and the Arab at 15 per cent. of the

	1881.	1896.
Native	2,850,886	3,847,448
French and naturalized .	269,502	334,713
Other Europeans . . .	190,014	211,535
Total	3,310,402	4,393,696

whole, but this estimate, due to General Faidherbe, is not easy to verify. The total population increased from 3,310,402 in 1881 to 4,393,696 in 1898. In those years the numbers of the native and of the European inhabitants are shown in the above table.

According to these figures, the native element increased by 28 per cent., the French by 25 per cent., and the non-French European by 12 per cent.

Of the European (non-French) population in 1896, 63,205 lived in the department of Algiers, 113,279 in the department of Oran, 35,051 in the department of Constantine. About half the number were Spanish; after them came Italians, Maltese, Germans, &c.

In 1896 the area and population of the three departments and the population of the military territory in each department were as follows:—

Departments	Area, Square Miles.	Total Population.	Population of Military Territory.
Algiers . .	65,929	1,526,867	218,461
Oran . .	44,616	1,028,248	140,071
Constantine .	73,921	1,838,781	202,611
Total	184,466	4,393,698	556,143

The area of the Algerian Sahara is about 123,500 square miles, and the population about 50,000.

Movement of population.—During three years the registered marriages, births, and deaths were as follows:—

Years.	Marriages.	Births.	Deaths.	Surplus of Births.
1897	37,140	133,164	78,951	54,213
1898	36,484	123,674	87,671	36,003
1899	42,816	135,479	90,557	44,922

In 1897 the divorces numbered 12,287; in 1898, 11,876; in 1899, 12,884. In those years, respectively, the still-births numbered 2423, 2837, and 2803. Of the living births in 1899, 17,637 were European, 2464 Jewish, and 115,274 Mussulman. In 1899, 1017 persons were naturalized. From 1865 to 1899, 25,611 were naturalized, of whom 8001 were Italian, 4816 Spanish, 6633 German, and 1315 Anglo-Maltese.

Algeria, in its three departments, contains 17 subordinate prefectures and 348 communes. The important towns are Algiers (96,784 inhabitants), Blidah (27,772), Médéa (16,235), Tizi-Ouzou, (27,466), in the department of Algiers; Constantine (51,997), Bône (34,498), Bougie (14,299), Guelma (7288), Philippeville (20,450), Sétif (16,061), in the department of Constantine; Oran (85,081), Mascara (22,203), Mostaganem (17,353), Tlemcen (34,866), in the department of Oran.

Government.—Algeria is administered by a civil governor-general. By decree of 28th August 1881, the budget of the colony was divided among the budgets of the various ministries, and the various services were placed under the direct authority of the respective ministers of France (a system called the *rattachement*), but, after the parliamentary inquiry of 1891, the system was modified, and the decree of 1st January 1897, augmenting the powers of the governor-general, suppressed the *rattachement*, except as regards worship, non-Mussulman justice, public instruction, and the customs. The governor is assisted by a superior council of government, the number of members of which was increased by a decree of 23rd August 1898. Another decree of the same date created the Algerian financial delegations, an elective body representing three categories of taxpayers: (1) the colonists, (2) taxpayers other than colonists, and (3) the natives. The duty of the delegations is to investigate all questions of taxation. Since 1900 Algeria has had a special budget of its own.

Education.—Algiers is the capital of an academic circumscription comprising the whole colony, and is besides the seat of an establishment for superior instruction consisting of faculties of law and of sciences, and a superior school of letters. The total number of students is 786, of whom 300 are students of law. Algeria has three *lycées* (at Algiers, Constantine, and Oran) with 2000 pupils, and nine communal colleges with 3863 pupils, besides a college for girls at Oran with 194 pupils. Most primary schools are Arab-French; the purely Arab are not numerous; some purely French exist. In the year 1897-98 the total number of primary schools was 1168, of which 489 were in the department of Algiers, 347 in that of Constantine, and 332 in that of Oran. The total number of pupils in the schools was 108,000, of whom 85,000 were boys and 43,000 girls. In the year 1897-98 the number of children at infant schools was 29,000. There are three superior Mussulman schools at Algiers, Tlemcen, and Constantine, where pupils are prepared for native employments.

Justice.—Justice is administered in the last resort by a court of appeal sitting at Algiers. There are sixteen tribunals of arrondissements or tribunals of first instance, besides tribunals of commerce and justices of the peace with extensive jurisdiction. Criminal justice is organized as in France. In 1897, 470 criminal charges were laid, resulting in 439 convictions; 71,210 persons were accused of minor offences and 21,228 of misdemeanours. In the penal establishments there were registered 50,223 entrances, of which 797 were for long terms of imprisonment and 49,426 (including 1416 women) were for shorter terms. Concurrently with the French there is a Mussulman system of justice for the decision of suits between natives. It is administered in the first instance by the cadis, whose sentences, on appeal, are within the jurisdiction of French courts.

Finance.—The increase of the expenditure is shown by the following budget estimates for 1880, 1890, and 1899 (25 francs = £1):—

Years.	Expenditure.
1880	£4,040,000
1890	4,920,000
1899	5,100,000

In 1899 the civil expenditure amounted to £2,920,000, the military to £2,080,000, and the pensions to £100,000. The receipts for 1899 were put at £2,168,000, of which £1,584,000 was from taxation, £218,000 from monopolies, and £178,000 from customs. The expenditure thus exceeded the receipts by £2,934,000, the deficit being met by the French Treasury, which besides providing for the military outlay contributes £860,000 towards the civil expenditure. But for a proper estimate of the cost of Algeria to France, besides the sums paid to the state as contributions to the public service, those paid to the departments and to the communes, amounting to about £1,600,000 annually, must be taken into account. Altogether Algeria spends about £8,680,000, towards which it contributes only £3,760,000.

Army.—The army constitutes the nineteenth French army corps. Its three divisions are at Algiers, Oran, and Constantine respectively, and contain a total strength of 80,800 rank and file. The elements of the divisions are the Zouaves (13,670), Algerian Rifles (15,249), the foreign legion (10,759), the African light infantry (8253), the African chasseurs (5314), and the Spahis (8532).

Agriculture.—By far the most important of the resources of the colony is agriculture, on which on 1st January 1898, 3,844,814 persons were estimated to be dependent, 207,310 being Europeans. At the same date the area cultivated was estimated at 26,182,000 acres, of which 7,647,100 acres were under wheat and other cereals (1,188,100 acres belonging to Europeans, and 6,459,000 acres to natives). In 1880 the area under cereals did not exceed 7,768,000 acres. The crops of wheat, barley, and oats yielded respectively 12, 16, and 1·2 millions of cwt. in 1880, and 14·6, 18, and 1·6 in 1898. In the latter year rye and maize yielded respectively 1,748,000 and 200,000 cwts. The cultivation of the vine, after encountering serious difficulties, has greatly extended. The vineyard area and produce in various years were:—

Years.	Acres.	Gallons.
1872	39,500	4,994,000
1880	55,800	9,504,000
1888	308,750	60,742,000
1898	348,270	100,194,600

The value of the wine-yield in 1898 was not less than £8,600,000 sterling. Of the three departments Oran produced the largest quantity, 40,772,600 gallons; then Algiers, 37,037,000 gallons; and Constantine, 22,385,000 gallons. Tobacco covers 17,330 acres, yielding 106,480 cwt. Early fruits are cultivated with success in the Mitija. There are about 7,000,000 olive-trees, which promise to become a source of wealth. Alfa-grass, an important article of commerce with England, grows on the high plateaus, where about 410,000 tons are annually gathered on an area of about 2,964,000 acres or 4630 square miles.

Forests.—The forests cover an area (chiefly on the mountain slopes) of about 7,410,000 acres, or 11,600 square miles. About 1,235,000 acres are in private ownership, 247,000 acres belong to communes, and the whole of the remainder is the property of the state. The cork-oak extends over an area of 684,000 acres, the zeen-oak and the aleppo pine belong to valuable species. The date-palm is cultivated in the oases; at Biskra there are 150,000 palm-trees; in the Ziban, 556,000; in the Wed Rir, 637,000; in the Souf, 180,000.

Live Stock.—The live stock in 1898 consisted of 202,343 horses, 142,796 mules, 255,870 asses, 205,827 dromedaries, 1,004,175 cattle, 7,026,290 sheep, 3,566,508 goats, and 90,765 pigs; in all, 12,494,574 animals, of which 831,457 belonged to non-natives and 11,663,117 to natives. The value of the agricultural material was estimated at £1,160,000 sterling.

Mines and quarries.—In the department of Algiers are coal-mines yielding about 10,000 tons of coal annually. Iron is mined at Mokta el Hadid, at Ain Mokra, and at other places; the yearly output being about 470,000 tons, worth £200,000 sterling. In the extraction of the ore about 1500 workpeople are employed. The zinc and lead mines yield about 43,000 tons, worth £55,000 sterling. Antimony is found in the department of Constantine. The phosphate beds recently discovered provide material for a rapidly increasing industry. They yielded 240,000 tons of phosphate in 1899. There are more than 300 quarries of stone, marble, &c. Salt is collected on the margins of the chotts or lakes on the high plateaus.

Industry.—Industries are not very active. The more important are pottery, employing 1520 workmen; shipbuilding, 256; tanning and leather-dressing, 2462; weaving and plaiting esparto goods, 9272; chemical works. In 1898 there were altogether 19,398 industrial establishments, employing 59,077 persons.

Commerce.—The principal imports are living animals, cereals, coffee, timber, coal, and tissues; while the chief exports are wine, alfa, tobacco, iron-ore, hides, cork, phosphates. The general trade (imports and exports) in 1870 amounted to the value of 12 millions sterling; in 1880 to 18·4 millions, in 1889 to 16·4 millions, in 1898 to 23·5 millions. The special trade in 1898 amounted to 11·8 millions sterling for imports and 10·6 millions for exports. The imports from France were of the value of 9 millions sterling, and the exports to France almost reached the same amount. France sends to Algeria tissues, ready-made clothing, furniture, metal goods, leather and leather goods; and receives from Algeria wine, cereals, sheep, wool, and horses. The imports from Great Britain reached the value of £248,000, and the exports to Great Britain £544,000. Other countries trading with Algeria were in 1898 (in order of importance) Morocco, Russia, Tunis, Spain, the United States, Italy, Brazil, and Belgium.

Shipping.—In 1898, 1834 vessels of 1,101,668 tons entered Algerian ports from abroad, and 1798 of 1,117,408 tons cleared for ports outside of Algeria. In the coasting trade, 8627 vessels, aggregating 1,621,623 tons, entered, and the same cleared. Direct shipping relations between Algeria and France are reserved exclusively for the national flag. The most frequented Algerian port is Algiers (1,700,000 tons), then Oran (1,000,000), Philippeville (500,000), and Bona (500,000). On 1st January 1899 the mercantile marine consisted of 657 sailing vessels of 7420 tons, and 64 steamers of 10,958 tons.

Railways.—In 1888 Algeria had 1740 miles of railway; in 1900, 2067 miles, of which 1357 were of normal gauge, besides 1134 miles under construction, of which 160 miles were of normal gauge. The principal lines are those from Algiers to Constantine, 290 miles; from Algiers to Oran, 266 miles; and the lines crossing or penetrating the country from Mostaganem to Am Sefra in the department of Oran, and from Philippeville to Biskra in the department of Constantine. The line from Algiers to Constantine is continued across the Tunisian frontier as far as the city of Tunis. The railway receipts in various years and the receipts per mile were as follows:—

Years.	Total Receipts.	Receipts per Mile.
1870	£94,000	£431
1880	489,600	594
1890	965,840	554
1896	968,000	500
1898	1,040,000	498

The receipts per mile have fallen off since 1880 owing to the construction of new lines.

Roads.—The length of the national roads in 1884 was 1784 miles; in 1888, 1794; in 1898, 1791.

Post-offices.—In 1897 there were 553 post-offices. The post and telegraph receipts in 1883 amounted to £150,600; in 1892 to £164,100; in 1897 to £183,000. The post-office orders issued in 1888 numbered 618,861 and were of the value of £1,364,818; in 1897, 925,498, of the value of £1,602,770. The payments into the post-office savings bank in 1888 amounted to £154,750; in 1897 to £387,940.

Banks.—The movement of coin and notes at the Bank of Algeria, whose head office is at Algiers, amounted in 1897-98 to over 56 millions sterling; that at the office of the Algerian Company to 52 millions; and at the five branches of the *Crédit Lyonnais* to 29½ millions. In 1897 the *Crédit Foncier et Agricole* of Algeria made advances to the amount of over 4 millions sterling.

History.—Since the great insurrection of 1871 there have been two revolts in Algeria, that of El Amri in 1876, and that of Bou Amama in 1881, in southern Oran, which was repressed not without difficulty. Another important event was the annexation of Myah (1882), where the inhabitants, tributary since 1853, had refused to fulfil their engagements. Since 1896 Algeria has suffered from the anti-Jewish agitation, which on several occasions, especially at Algiers, Oran, and Constantine, has led to riot and bloodshed. In consequence of the difficulties raised by this propaganda, there has lately been a constant change in governors (see also ANTI-SEMITISM).

AUTHORITIES.—*Statistique générale de l'Algérie.* Alger, 1899. —*Annuaire statistique de la France.* Paris.—DUBOIS et KERGOMARD. *Géographie économique.* Paris, 1898. — LAFERRIÈRE. *Exposé de la situation générale de l'Algérie.* Mustapha, 1899.— WAHL. *L'Algérie* (last edition). Paris, 1899.—VIGNON. *La France dans l'Afrique du Nord.* Paris, 1897. — GAFFAREL. *L'Algérie.* Paris, 1888. — D'HAUSSONVILLE. *La colonisation officielle en Algérie.* Paris, 1883. (P. L.)

Algiers, capital city and seaport of Algeria, the seat of the government-general, of a court of appeal, and of an archbishop, and station of the 19th Corps d'Armée. Taking into account only the ancient Algiers within the circuit of the city walls to the exclusion of the suburban faubourgs, the population, 48,908 in 1872, had increased to 82,585 in 1891, and reached 96,784 in 1900. The French population, 18,216 in 1872 and 38,041 in 1891, numbered 42,004 in 1900; but this increase was mainly due to the facilities offered for the acquisition of writs of naturalization. The Jews numbered 7857; the Arabs, 23,202; foreigners, 23,721. Including the suburban faubourgs from the Pointe Pescade to Maison Carrée, namely, St Eugène, Hussein Dey, Busarea, El-Biar, El-Kouba, to mention only the most important groups of population, the inhabitants of Algiers in 1900 numbered 135,000 against about 66,000 within the same area in 1872. Such a marked growth of population is to be ascribed to the extension of commerce, of shipping, of the public services, and of agriculture. Resting on high hills all covered with gardens, Algiers enjoys a delightful situation, and has become one of the most frequented winter resorts. The old Algiers of narrow and steep streets, crowned by the Citadel, the Kasbah, is distinguished from the new Algiers, on level ground, which has for its principal road the superb Boulevard de la République. The chief public buildings are the Government House (Palais du Gouvernement), the cathedral, the Grand Mosque, the library, and museum. The old walls of Algiers will soon be completely demolished, and in their place will be planted a line of forts which will occupy the edge of Mount Busarea at an elevation of over 1300 feet above the sea. The port of Algiers is to be entirely transformed, the Chamber of Commerce and the Government having taken the necessary measures to push forward the works rapidly. The main object is to do away with the sorry port of Agha. At present, however, a public warehouse has been established in connexion with the loading and unloading of the goods. The jetty to the south of the port has been enlarged, pending the extension of the north jetty. Owing to the improvement already accomplished, Algiers has become one of the most considerable colonial maritime *entrepôts.* The tonnage, which in 1883 did not exceed 314,633, entered and cleared, amounted in 1894 to 924,616, and in 1898 to 1,702,310. In short, Algiers engrosses more than 40 per cent. of the total traffic of Algeria. The merchant ships at the port numbered, in 1898, 250 of 10,348 tons, or 72 per cent. of the total tonnage of the merchant marine of Algeria. The seat of a college, with schools of law, medicine, science, and letters, Algiers in 1898 counted 1069 students of higher instruction—509 in letters, 64 in science, 230 in medicine, and 266 in law. Algiers maintains communication with Marseilles by a quick service of steamers, which run the 497 miles across the Mediterranean in twenty-eight to thirty hours. The journey between Algiers and Paris, from which it is distant 1031 miles, is accomplished in about forty-five hours.

AUTHORITIES.—TARDIEU. *Alger tel qu'il est.* 1887.—DROUET. *Alger et le Sahel.* 1887.—WAHL. *L'Algérie.* 1897.—PENSA. *Algérie: Voyage de la délégation de la Commission d'Études,* &c. 1894.—PIESSE. *Algérie* (Guide Joanne).—PLAYFAIR. *Handbook* (Murray's) *of Algeria and Tunis.* 1895. (P. L.)

Alhama de Granada, a town in the province of Granada, Spain. Population, 7382. In 1884 five churches, the hospital, the prison, the theatre, and more than a thousand houses were destroyed by an earthquake. Eight hundred persons were buried under the ruins. A new town was built near the old one, mostly by subscriptions raised in the rest of Spain. Strange to say, the baths, situate outside the town, were not much injured.

Aliaga, a town of 17,000 inhabitants in the west-central portion of the province of Nueva Ecija, Luzon, Philippine Islands. It is well situated in the midst of a rich Indian corn, rice, sugar, and tobacco-producing region, and has a comparatively cool and healthful climate. Tagalog is the most important language; Ilocano, Pampango, and Pangasinan are also used.

Alicante, a maritime province in the S.E. of Spain, with an area of 2096 square miles. Population (1897), 451,174. The coast-line has an extent of 107 miles. The roads are not in very good condition. Railways run through the province from Alicante to Madrid, and to Murcia, and the south of Spain. The province is divided into 14 districts and 138 parishes. There are, in working condition, 7 mines of iron ore, 2 of lignite, and 2 salt-mines. The salt-mines of Torrevieja employed 561 men, and produced in 1898 93,493 tons of the estimated value of £31,082. The live stock in the province includes 4031 horses, 14,960 mules, 8908 donkeys, 2160 oxen and cows, 52,790 sheep, 19,461 goats, and 6555 pigs. Wheat is grown on 9000 acres, rye, oats, barley, and maize on 59,000, vines on 259,000, olive on 41,250. The births in the province average five to every four deaths. The population does not increase, however, owing to the emigration, mainly to Oran in Algeria. Only the provinces of Almerin and Pontevedra show more emigrants annually than Alicante.

Alicante, a town of Spain, capital of the above province, and a resort in winter for invalids on account of its mild and steady climate. Population in 1897, 49,463. Alicante was more affected than the other Mediterranean ports in 1898 when Spain lost her colonies, after her struggle with the United States, as is shown by the figures of the shipping at the port in 1897 and 1898. In 1897 the return of all the shipping gives 1769 vessels, with 1,475,994 tons, and in 1898, 1660 vessels, with 1,008,937 tons. The coasting trade has been on the increase for several years, and this partly explains how 1250 Spanish vessels, with 836,795 tons, rank in the returns for 1898. The principal exports were wines, valued at £700,000 in 1897, and £800,000 in 1898; lead, valued at £160,000 in 1897, and £150,000 in 1898; almonds, valued at £60,000 in 1897, and £65,000 in 1898; esparto, valued at £10,000 in 1897, and £20,000 in 1898; saffron, valued at £75,000 in 1897, and £40,000 in 1898.

Alice Maud Mary, GRAND-DUCHESS OF HESSE-DARMSTADT (1843-1878), second daughter and third child of Queen Victoria, was born at Buckingham Palace, 25th April 1843. A pretty, delicate-featured child—"cheerful, merry, full of fun and mischief," as her elder sister described her—fond of gymnastics, a good skater, and a devoted rider, she was a general favourite from her earliest days. Her first years were passed without particular incident in the home circle, where the training of their children was a matter of the greatest concern to the Queen and the Prince Consort. Among other things, the royal children were encouraged to visit the poor, and the effect of this training was very noticeable in the later life of Princess Alice. After the marriage of the Princess Royal in 1858, the new responsibilities devolving upon Princess Alice, as the eldest daughter at home, called forth the higher traits of her charactor, and brought her into still closer relationship with her parents, and especially with her father. In the summer of 1860, at Windsor Castle, Princess Alice first met her future husband, Prince Louis of Hesse. An attachment quickly sprang up, and on the prince's second visit in November they were formally engaged. In the following year, on the announcement of the contemplated marriage, the House of Commons unanimously voted a dowry of £30,000 and an annuity of £6000 to the princess. In December 1861, while preparations were being made for the marriage, the Prince Consort was struck down with typhoid fever, and died on the 14th. Princess Alice nursed her father during his short illness with the utmost care, and after his death devoted herself to comforting her mother under this terrible blow. Her marriage took place at Osborne, on 1st July 1862. The princess unconsciously wrote her own biography from this period in her constant letters to Queen Victoria, a selection of which were allowed to be printed in 1883. They first appeared in Germany, under the editorship of Doctor Sell; the English edition which followed being edited by Princess Helena (Princess Christian). These letters give a complete picture of the daily life of the duke and duchess, and they also show the intense love of the latter for her husband, her mother, and her native land. She managed to visit England every year, and it was at her special request that when she died her husband laid an English flag upon her coffin.

In the war between Austria and Prussia in 1866, Hesse-Darmstadt was upon the side of the Austrians; Prince Louis accompanied his troops to the front, and was duly appointed by the grand-duke to the command of the Hessian division. This was a time of intense trial to the princess, whose husband and brother-in-law, the crown prince of Prussia, were necessarily fighting upon opposite sides. The duke of Hesse also took part in the principal battles of the Franco-Prussian war, while the duchess was actively engaged in organizing hospitals for the relief of the sick and wounded. The death of the duke's father, Prince Charles of Hesse, on 20th March 1877, was followed by that of the grand-duke on 13th June, and Prince Louis succeeded to the throne as Grand Duke Louis IV. In the summer of 1878 the grand-duke and duchess, with their family, came again to England, and went to Eastbourne, where the duchess remained for some time. She returned to Darmstadt in the autumn, and on 8th November 1878 her daughter, Princess Victoria, was attacked by diphtheria. Three more of her children, as well as her husband, quickly caught the disease, and the youngest, "May," succumbed on the 16th. On 7th December the princess was herself attacked, and, being weakened by nursing and anxiety, had not strength to resist the disease, which proved fatal on 14th December, the seventeenth anniversary of her father's death. In a sermon preached on the day after her death, Canon Duckworth admirably summed up the character of the princess: "Endowed with rich intellectual gifts, and with a force and charm of character which would have made her a conspicuous power in any rank, the princess whom we mourn has passed her brief days in unwearied use of great opportunities." She left one son and four daughters. (G. F. B.)

Aligarh, a city and district of British India, in the Meerut division of the North-West Provinces. The city, also known as Koil, is a station on the East Indian railway, 876 miles from Calcutta. Sir Sayad Ahmad Khan, K.C.S.I., who died in 1898, founded in 1864 the Aligarh Institute and Scientific Society for the translation into the vernacular of western literature; and afterwards the Mahommedan Anglo-Oriental College, under English professors, with an English school attached. In 1896-97 the college had 114 students, and meets with strong support from the enlightened portion of the Mussulman community, whose aim is to raise it to the status of a university, with the power of conferring degrees. Population (1881), 61,730; (1891), 61,485; (1901), 70,127, showing an increase of 14 per cent; the municipal income in 1897-98 was Rs.63,923; the death-rate in 1897 was 40 per thousand. There are three flour-mills, several cotton-presses, and a dairy farm.

The district of ALIGARH is traversed by several railways, and also by the Ganges Canal, which is navigable. The chief trading centre is Hathras. Area, 1952 square miles; population (1891), 1,043,172, being 534 persons per square mile; (1901), 1,203,047, showing an increase of 15 per cent., due to the extension of irrigation. The land revenue and rates are Rs.25,97,223, the incidence of assessment being R.1:11:4 per acre; the cultivated area in 1896-97 was 889,182 acres, of which 526,667 were irrigated from wells, &c.; the number of police was 2954; there are 78 vernacular schools, with 6979 pupils; the registered death-rate in 1897 was 34 per thousand. There are 12 factories for ginning and pressing cotton, and 182 indigo factories, with an out-turn which is valued at Rs.6,88,000.

Alipur. See CALCUTTA.

Alirajpur, a native state of India, under the Bhopawar agency. It lies in Malwa, near the frontier of Bombay. It has an area of 837 square miles; and a population (1891) of 70,091, being 84 persons per square mile. The country is hilly, and many of the inhabitants are aboriginal Bhils. It has from time to time been under British administration. The chief, whose title is Rana, is a Rahtor Rajput. He has an estimated revenue of Rs.130,633, and pays a tribute of Rs.11,000. The town of Alirajpur is situated in 22° 11′ N. lat. and 74° 24′ E. long. The Victoria bridge was built to commemorate the Diamond Jubilee of 1897.

Alison, Sir Archibald, BART. (1826——), G.C.B., British general and colonel of the Seaforth Highlanders, eldest son of the first baronet, the well-known historian, was born at Edinburgh, on 21st January 1826. Educated at Glasgow and Edinburgh Universities, he entered the 72nd Highlanders as ensign in 1846. He was promoted captain in 1853, and served in the Crimean campaign at the siege of Sebastopol (medal with clasp, Turkish medal, brevet majority). During the Indian Mutiny he was military secretary to Sir Colin Campbell, commander-in-chief, and was severely wounded at the relief of Lucknow, losing an arm (medal with clasp, brevet lieut.-colonelcy, C.B.). From 1862 to 1873 he served on the staff as an assistant adjutant-general at headquarters, Portsmouth, and Aldershot. He commanded the European brigade, and was second in command of the Ashanti Expedition 1873-74, distinguishing himself at the battle of Amoaful, capture of Bequah, action of Ordahsu, and capture of Kumassi (medal with clasp, thanks of parliament, and K.C.B.). For three years Alison was deputy adjutant-general on the headquarters staff in Ireland and then, for a few months, commandant of the Staff College. He was promoted to be major-general in 1877, and from 1878 to 1882 was head of the intelligence branch of the War Office. He commanded the troops at Alexandria in 1882 until the arrival of Sir Garnet Wolseley, commanded the Highland Brigade at the battle of Tel-el-Kebir in the Egyptian campaign, and remained in command of the army of occupation of Egypt until 1883 (medal with clasp, bronze star, second class Osmanieh, thanks of parliament, and promoted lieut.-general for distinguished service). He commanded the Aldershot division from 1883 to 1888, was for some months adjutant-general to the forces during Lord Wolseley's absence in Egypt, was made G.C.B. in 1887, and was promoted general and became a military member of the Council of India in 1889.

Aliu-amba. See ABYSSINIA.

Aliwal, a village of British India, in the Ludhiana district of the Punjab, situated in 30° 57′ N. lat. and 75° 37′ E. long., on the left bank of the Sutlej. Here, on 28th June 1846, Sir Harry Smith, in command of a cavalry force, inflicted a severe defeat upon the Sikhs.

Aliwal North, a town of Cape Colony, on the left bank of the Orange river, which is here spanned by a fine bridge, 860 feet long. The town is the present terminus of the line running from East London through Molteno and Burghersdorp northwards, and carries on a brisk trade with the Orange River Colony and surrounding districts. The population is about 3000. Aliwal North is so named to distinguish it from ALIWAL SOUTH, which is the seaport of the pastoral Grasveld district, and stands on the west side of Mossel Bay under the Cape St Blaize headland, by which it is sheltered from the fierce southern winds. It has a considerable import and export trade, ranking in this respect fourth amongst the seaports of Cape Colony. The population is about 3000.

Alkmaar, a town of the Netherlands, in the province of North Holland, about 20 miles N.N.W. of Amsterdam by rail. It is also connected by steam tramway (1896) with Purmerend, Amsterdam, and Hoorn. There is a military school here. Population in 1870, 11,410; in 1900, 18,275.

Allada. See DAHOMEY.

Allahabad, a city of British India, the capital of the North-West Provinces, also a district and a division. The city is situated at the confluence of the Ganges and the Jumna, 564 miles from Calcutta by rail. Modern buildings include Government House, the High Court, the Mayo memorial and town hall, the Muir Central College, the Thornhill and Mayne memorial library and museum, the Naini central jail, Trinity church, and the Roman Catholic cathedral. The Jumna is crossed by a railway bridge, and there are two bridges of boats over the Ganges. The military cantonments contain accommodation for all three arms. Population (1881), 148,547; (1891), 175,246; (1901), 175,748. The municipal income in 1897-98 was Rs. 3,93,283; the registered death-rate in 1897 was 36·5 per thousand. The municipality consists of 28 members, of whom 21 are elected, with the magistrate as *ex officio* chairman. The water-supply, which was extended in 1897, provides 1,425,000 gallons a day, or 8 gallons per head. In 1896-97 the Muir Central College had 195 students; the Kayasth Pathsala had 73 students. There are four high schools and an American mission. There are 33 printing presses, 4 English and 4 vernacular newspapers, a literary institute, the Kayasth association, a Mahommedan union, and debating society.

The district of ALLAHABAD is traversed by the East Indian railway and the Great Trunk road. Apart from the city, it contains no town with a population exceeding 5000. Area, 2852 square miles; population (1891), 1,548,737, being 543 persons per square mile; (1901), 1,487,904, showing a decrease of 4 per cent. The land revenue and rates are Rs.19,12,757, the incidence of assessment being R.1:5:3 per acre; the cultivated area in 1896-97 was 882,887 acres, of which 232,774 were irrigated from wells and tanks; the number of police was 4745; there are 217 vernacular schools, with 5941 pupils; the registered death-rate in 1897 was 45 per thousand. The principal crops are rice, millet, pulse, barley, cotton, opium, and indigo.

There are 23 indigo factories, with an out-turn valued at Rs.1,09,000.

The division of ALLAHABAD has an area of 17,265 square miles. Population (1891), 5,757,121, being 333 persons per square mile; (1901), 5,535,803, showing a decrease of 4 per cent., due to the famine of 1896-97, which was severely felt in this tract. It comprises the eight districts of Cawnpore, Fatehpur, Banda, Hamirpur, Allahabad, Jhansi, Jalaun, and Lalitpur.

Allegheny, a city of Pennsylvania, U.S.A., situated in lat. 40° 27′ N. and long. 80° 00′ W. on the north bank of the Allegheny and Ohio rivers, opposite Pittsburg, with which it forms a single business and manufacturing community. The elevation above sea-level at the station of the Pennsylvania Railroad, in the lower part of the city, is 736 feet, most of the city being much higher. The main position is on a plateau immediately above the rivers, with residence portions extending over the hills behind. The river part is occupied by manufacturers, while the principal mercantile quarter is along Federal and Ohio streets, which intersect at a central square, containing the city hall, post office, Carnegie free library, and the market-place. The parks consist of the east, north, and west parks, nearly surrounding the central business section, and Riverview Park on the hills about two miles to the north. The population in 1890 was 105,287; in 1900, 129,896, with a death-rate of 16·23. The higher institutions of learning are the Western University of Pennsylvania and theological seminaries of the Presbyterian and United Presbyterian churches. In the lower part of the city is the Riverside State Penitentiary. The government consists of a mayor, and departments of public safety, public works, and public charity, with select and common councils. The annual expenditure is $2,099,000, the debt is $4,810,588, and the valuation of property $81,601,300. There are three hospitals, ten banking institutions, and four insurance companies. It has extensive manufactures, amounting in 1890 to $20,500,000, mainly of iron, leather, and paint. Three railways, the Pennsylvania, the Pittsburg and Western, and the Buffalo, Rochester, and Pittsburg, enter the city.

Allenstein, a town of Prussia, province East Prussia, 100 miles by rail N.E. from Thorn. It has a mediæval episcopal castle, a couple of churches, a synagogue, a lunatic asylum, and various industries — iron-foundries, saw-mills, brick-works, and breweries; also a trade in cereals and timber. Population (1885), 11,555; (1895), 21,579; (1901), 24,307.

Allentown, a city of Pennsylvania, U.S.A., the capital of Lehigh county, situated in 40° 37′ N. lat. and 75° 27′ W. long., in the eastern part of the state, in Lehigh Valley, at an altitude of 256 feet, sixty miles north by west from Philadelphia. Though its site is hilly, its plan is quite regular. The city is divided into eleven wards, and is entered by four railways, the Central of New Jersey, the Lehigh Valley, the Perkiomen, and the Philadelphia and Reading. It has important manufactures of boots and shoes, iron and silk. It is the site of Muhlenburg College. The population in 1880 was 18,063, in 1890 it was 25,228, and in 1900 it was 35,416.

Alleppi, or AULAPALAY, a seaport of Southern India, in the state of Travancore, 33 miles south of Cochin, situated on a strip of coast between the sea and one of those backwaters that here form the chief means of inland communication. There is a lighthouse, 85 feet high, with a revolving white light visible 18 miles out at sea. The exports consist of coffee, pepper, cardamoms, and cocoa-nuts. There are two factories for coir matting. The Raja has a palace, and Protestant missionaries have a church. Population (1891), 22,768.

Aller, a town of Spain, in the province of Oviedo, 21 miles S.E. of Oviedo, on the coast side of the Picos de Europa that separate the basin of the rivers running towards the sea from the dry plateau of Old Castile. It stands in the midst of a wooded country, and in the neighbourhood are coal and iron-ore mines and an iron foundry. There are two churches and schools. Population (1897), 11,975.

Alliance, a city of Stark county, Ohio, U.S.A., situated in the north-east part of the state, at an altitude of 1081 feet, on three lines of railway. It is the seat of Mount Union College. Its manufactures consist in great part of agricultural tools and machines. The population in 1880 was 4636, in 1890 it was 7607, and in 1900 it was 8974.

Allier, a department in the centre of France. It is traversed by the ramifications of the mountains of Dôme and of the Forez, and watered by the Allier and the Cher. Its area occupies 2850 square miles. The department comprises 29 cantons, 321 communes, and had a population in 1901 of 422,083, against 424,582 in 1886. Births (1899), 7999, of which 463 were illegitimate; deaths, 7236; marriages, 3590. The towns are Moulins (22,415 inhabitants in 1896), Gannat, La Palisse, Commentry, Montluçon, and Vichy. In 1896 there were 872 primary schools, with 60,688 pupils, and 9 per cent. of the population was illiterate. The area under cultivation measured 1,660,255 acres, of which 1,185,600 acres were in forest and 34,580 acres in vineyards. In 1899 the wheat crop yielded a value of £1,804,210, and the vines £200,000. The live stock (1899) numbered 742,510 head, of which 275,900 were cattle. Allier counts among the departments of France in which the mining industry is in a forward state. It produces a million tons of coal yearly in the basin of Commentry. The industry in metals has likewise assumed large proportions around Montluçon, turning out 69,000 tons of iron, cast-iron, and steel, of the value of £700,000, in 1898. The other industries are in glass, in paper, in chemical products (Commentry), and in cutlery (St Pourçain).

Allingham, William (1824-1889), Irish man of letters and poet, was born at Ballyshannon, Donegal, 19th March 1824 (or 1828, according to some authorities), and was the son of the manager of a local bank. He obtained a post in the custom-house of his native town and filled several similar situations in Ireland and England until 1864, when he became sub-editor of *Fraser's Magazine*, which he subsequently edited until 1879. He had made himself known by the publication of a volume of poems in 1850, followed by *The Music Master* and *Day and Night Songs*, a volume containing many charming lyrics, in 1855, and by *Laurence Bloomfield*, a narrative poem illustrative of Irish social questions, in 1864. He married Helen Paterson, known under her wedded name as a distinguished water-colour painter, and died at Hampstead on the 18th of November 1889. Though working on an unostentatious scale, Allingham produced much excellent lyrical and descriptive poetry, and the best of his pieces are thoroughly national in spirit and local colouring.

Allman, George James (1812-1898), British biologist, was born in Cork, Ireland, in 1812, and received his early education at the Academical Institution, Belfast. For some time he studied for the Irish bar, but ultimately gave up law in favour of natural science. In 1844 he graduated in medicine at Dublin, and was at once appointed Professor of Botany in that university. This position he held for about twelve years until he removed to Edinburgh as Regius Professor of Natural History.

There he remained till 1870, when considerations of health induced him to resign his professorship and retire to Dorsetshire, where he devoted himself to his favourite pastime of horticulture. The scientific papers which came from his pen are very numerous. His most important work was upon the gymnoblastic hydrozoa, on which he published in 1871-72, through the Ray Society, an exhaustive monograph, based largely on his own researches and illustrated with drawings of remarkable excellence from his own hand. Biological science is also indebted to him for several convenient terms which have come into daily use, *e.g.*, *endoderm* and *ectoderm* for the two cellular layers of the body-wall in Cœlenterates. He became a Fellow of the Royal Society in 1854, and received a Royal medal in 1873. For several years he occupied the presidential chair of the Linnæan Society, and in 1879 he presided over the Sheffield meeting of the British Association. He died 24th November 1898.

Alloa, a river port and police burgh on the north side of the Forth in the county of Clackmannan, Scotland, 28 miles from Leith by water, and 6½ miles E. of Stirling by rail. The register of shipping included 7 vessels of 374 tons at the end of 1898; in 1898 entered 918 vessels of 177,004 tons, cleared 1056 of 201,576 tons. Coal is the chief article of export, 345,631 tons being shipped in 1898. There are in the town 8 breweries. Spinning mills (its yarn is famous), engineering works, and chemical works are among the industrial features. The parish church has been restored internally, and recent erections are a hall and museum, a town hall and free public library (designed by Mr. Waterhouse, R.A., the gift of Mr. J. Thomson Paton), a county combination hospital, a secondary school, public baths and gymnasium, and an accident hospital. A public park has been opened. One of the schools is an academy. Population of police burgh in 1881, 8812; 1891, 10,754; 1901, 11,417.

Allotments and Small Holdings.—As the meaning of these terms varies in different localities, it may be as well to say at once that for the present purpose they are definable as pieces of land detached from cottages, and hired or owned by labouring men to supplement their main income. We do not include any farm, however small, from which the occupier derives his main support by dairying, market-gardening, or other form of *la petite culture*. So also, no account is taken of the tiny garden plot, used for growing vegetables for the table and simple flowers, which is properly an appurtenance of the cottage. Clearing away what is extraneous, the essential point round which much controversy has raged is the labourer's share in the land. To some extent this depends upon tradition. In agriculture, the oldest of all industries, a cash payment is not even now regarded as discharging the obligations between master and servant. Mr Wilson Fox, in reporting to the Board of Trade on the earnings of agricultural labourers in Great Britain, gives, as a typical survival of an old custom, the case of a shepherd whose total income was calculated at £60 a year, but who got only £16 in money, the rest being made up by rights of grazing live-stock and growing crops on his master's land, and kindred privileges. That is exactly in the spirit that used to pervade agriculture, and doubtless had its origin in the manorial system. If we turn back to the 13th century, from Walter de Henley's *Husbandry* it will be seen that practically there were only two classes engaged in agriculture, and corresponding with them were two kinds of land. There were, on the one hand, the employer, the lord, and his demesne land; on the other, the villans, and the land held in villenage. Putting aside for the moment any discussion of the exact degree of servitude, it will be seen that the essence of the bargain was that the villan should be permitted to cultivate a virgate of land for his own use in return for service rendered on the home farm. This is not altered by the fact that the conditions approached those of slavery, that the villans were *adscripti glebæ*, that in some cases their wives and sons were bequeathed by deed to the service of religious houses, and that in many other respects their freedom was limited. Out of this, in the course of centuries, was developed the system prevailing to-day. Lammas lands are indeed a survival from it. There are in the valley of the Lea, and close to London, to take one example, lands allotted annually in little strips till the crops are carried, when, the day being fixed by a reeve, the land becomes a common pasture till the spring closing takes place once more. Perhaps the feature of this old system that bears most directly on the question of allotments was the treatment of the waste of the manor. The lord, like his tenants, was limited by custom as regards the number of beasts he could graze on it. After the havoc of the Black Death in 1349, many changes were necessitated by the scarcity and dearness of labour. It became less unusual for land to be let and for money payment to be accepted instead of services. There was a great demand for wool, and to conduct sheep-farming on a large scale necessitated a re-arrangement of the manor and the enclosure of many common fields under the statute of Merton and the statute of Westminster Second. Nevertheless, up to the 18th century, a vast proportion of agricultural land was technically waste on which rights of common were exercised by yeomen, some of whom had acquired holdings by the ordinary methods of purchase or inheritance, while others had merely squatted and built a house on the waste. It is to this period that belongs a certain injustice to which the peasantry were subject. No reasonable doubt can be entertained of the necessity of enclosure. Husbandry, after long stagnation, was making great advance; and among others, Arthur Young raised his voice against the clumsy inconvenient common fields that were the first to be enclosed. Between 1709 and 1797 no fewer than 3110 Acts, affecting, as far as can be calculated, about 3,000,000 acres, were put into operation. They seem mostly to have been directed to the common fields. In the first half of the 19th century the movement went on apace. In a single year, 1801, no fewer than 119 Acts were passed; and between 1801 and 1842 close on 2000 Acts were passed—many of them expressly directed to the enclosure of wastes and commons. The same thing continued till 1869. It touched the peasant directly and indirectly. The enclosure of the common fields proved most hurtful to the small farmer; the enclosure of the waste injured the labourer by depriving him, without adequate compensation, of such useful privileges as the right to graze a cow, a pig, geese, or other small animals. It also discouraged him by tending to the extinction of small tenancies and freeholds that were no longer workable at a profit when common rights ceased to go with them. The industrious labourer could previously nourish a hope of bettering his condition by obtaining a small holding. Yet, though the labourer suffered, impartial study does not show any intentional injustice. He held a very weak position when those interested in a common affixed to the church door a notice that they intended to petition. As Mr Cowper said in the House of Commons on 13th March 1844, "the course adopted had been to compensate the owner of the cottage to whom the common right belonged, forgetting the claims of the occupier by whom they were enjoyed"; and in the same debate Sir Robert Peel pointed out that not only the rights of the tenant, but those of his successors ought to have been studied. The course adopted divorced the labourer from the soil.

Parliament, as a matter of fact, had from a very early period recognized the wisdom of contenting the peasant. In the 14th century England was a land of small farms wherein the tenant lived in rude abundance. Next century a rural exodus began, owing to the practice of enclosing the holdings and turning them into sheep walks. In 1487 an Act was passed enjoining landlords to "keep up houses of husbandry," and attach convenient land to them. Within the next hundred years a number of similar attempts were made to control what we may call the sheep fever of the time. Then we arrive at the reign of Elizabeth and the famous Small Holdings Act passed in 1597—an anticipation of the three-acres-and-a-cow policy advocated towards the end of the 19th century. It required that no person shall "build, convert, or ordain any cottage for habitation or dwelling for persons engaged in husbandry" unless the owner "do assign or lay to the same cottage or building four acres of ground at the least." It also provided against any "inmate or under-sitter" being admitted to what was sacred to one family. This measure was not conceived in the spirit of modern political economy, but it had the effect of staying the rural exodus. It was repealed in 1775 on the ground that it restricted the building of cottages. By that time the modern feeling in favour of allotments had begun to ripen, and it was contended that some compensation should be made to the labourers for depriving them of the advantages of the waste. Up to then the English labouring rustic had been very well off. Food was abundant and cheap, so were clothes and boots; he could graze his cow or pig on the common, and also obtain fuel from it. Now he fell on evil days. Prices rose, wages fell, privileges were lost, and in many cases he had to sell the patch of land the possession of which made all the difference between hardship and comfort. All this was seen plainly enough both by statesmen and private philanthropists. One of the first experiments was described by Sir John Sinclair in a note to the report of a select committee of the House of Commons on waste lands in 1795. About 1772 the lord of the manor of some commonable lands near Tewkesbury had with great success set out 25 acres in allotments for the use of some of the poor. Sir John was very much struck with the result, and so heartily applauded the idea that the committee recommended that any general Enclosure Bill should have a clause in it providing for "the accommodation of land." Sir Thomas Bernard and Mr Wilberforce took an active part in advocating the principle of allotments, on the ground, to summarize their argument in language employed later by a witness before the House of Commons, that "it keeps the cottagers buoyant and makes them industrious." In 1806, at the suggestion of the rector, a clause assigning an allotment of half an acre to every cottage was inserted in an Enclosure Bill then under consideration for the parish of Broad Somerford in Wiltshire. This was done, "and the example was followed by nearly every adjoining parish in that part of Wiltshire." Passing over several praiseworthy establishments of allotments by private persons, we come to 1819, when Parliament passed an Act akin in spirit to several that came into existence during the later portion of the Victorian era. It empowered the churchwardens and overseers of any parish, with the consent of the vestry, to purchase or hire land not exceeding 25 acres, and to let it in portions to "any poor and industrious inhabitant of the parish." This was amended in 1831 by an Act extending the quantity of land to 50 acres, and also conveying an important new power to enable the same authorities to enclose from any waste or common land not exceeding 50 acres to be devoted to the same purpose. This was followed next year by an Act relating to fuel, and in 1834 the Poor Law Commissioners reported favourably on the principle of granting allotments. In 1843 an important inquiry into the subject was made by a committee of the House of Commons, which produced a number of valuable suggestions. One consequence was the Bill of 1845, brought into Parliament by Mr Cowper. It passed the House of Commons; and there Mr Bright made a remark that probably summarized a general opinion, since it never came to a third reading in the House of Lords. He said that "the voluntary system of arrangement would do all the good that was expected to accrue from the allotment system."

At this point in the history of the movement it may be as well to pause and ask what was the net result of so much legislation and benevolent action. Messrs Tremenheere and Tufnall, who prefixed an admirable epitome of what had been done to the report of the Commission "appointed to inquire into the employment of women, young persons, and children in agriculture" (1867), expressed considerable disappointment. Between 1710 and 1867, 7,660,413 statute acres were added to the cultivated area of England and Wales, or about one-third of the area in cultivation at the latter date; and of this total, 484,893 acres were enclosed between 1845 and 1867. Of the latter, only 2119 acres were assigned as public allotments for gardens to the labouring poor. It was found to be the case, as it is now, that land was taken up more readily when offered privately and voluntarily than when it came through official sources. Meanwhile competent and thoughtful men saw well that the sullen discontent of the peasantry continued, in Lord Bacon's phrase, to threaten "the might and manhood of the kingdom." It had existed since the beginning of the Napoleonic wars, and had become more articulate with the spread of education. We shall see a consciousness of its presence reflected in the minds of statesmen and politicians as we briefly examine the later phase of the movement. This found expression in the clauses against enclosure introduced by Lord Beaconsfield in 1876, and gave force to the three-acres-and-a-cow agitation, of which the more prominent leaders were Mr Joseph Arch and Mr Jesse Collings. In 1882 the Allotments Extension Act was passed, the object of which was to let the parishioners have charity land in allotments, provided it or the revenue from it was not used for apprenticeship, ecclesiastical, or educational purposes. A committee of the House of Commons, appointed in 1885 to inquire into the housing of the working classes, reported strongly in favour of allotments, and this was followed in 1887 by the Allotments Act—the first measure in which the principle of compulsory acquisition was admitted in regard to other than charity lands. Its administration was first given to the Sanitary Authority, but passed to the District Councils when these bodies were established in 1894. The local body is empowered to hire or purchase suitable land, and if they do not find any in the market they are to petition the County Council, which after due inquiry may issue a provisional order compelling owners to sell land, and the Local Government Board may introduce a Bill into Parliament to confirm the order. It was found that the Sanitary Authority did not carry out the scheme, and in 1890 another Act was passed for the purpose of allowing applicants for allotments, when the Sanitary Authority failed to provide land, to appeal to the County Council. Judging from the evidence laid before the commission on agricultural depression (1894), the Act of 1887 has not been a conspicuous success. Most of the witnesses reported in such terms as these—"the Allotments Act has been quite inoperative in Cornwall"; "the Act has been a dead letter in the district (Wigtownshire)"; "the Allotments Act has not been in operation in Flintshire"; "nothing has been done in the district of

Pembrokeshire under the Act." No evidence whatever was adduced to show that in a single district a different state of things had to be recorded. From a return presented by the Local Government Board to Parliament in 1896 we learn that eighty-three rural sanitary authorities had acquired land for allotment prior to the 28th December 1894, the date at which these authorities ceased to exist under the provisions of the Local Government Act 1894. Land was acquired by compulsory purchase in only one parish; by purchase or agreement in eighteen parishes; by hire by agreement in 132 parishes. The total acreage dealt with was 1836 acres 1 rood 34 poles, and the total number of tenants 4711. The number of County Councils that up to the same date had acquired land was twelve, and they had done so by compulsory purchase in one parish, by purchase or agreement in five parishes, by hire by agreement in twenty-four parishes. The total area dealt with was only 413 acres 1 rood 5 poles, and the total number of tenants 825. The complete totals affected at the date of the return, 21st August 1895, by the Acts, therefore, were 2249 acres 2 roods 39 poles, and 5536 tenants. A considerable extension has taken place since, but before dealing with that point a word should be said of a measure closely akin to the allotments legislation—viz., the Small Holdings Act introduced by Mr Henry Chaplin, and passed by Parliament in 1892. It was an attempt to appease the rural discontent that had been seething for some time past and was silently but most eloquently expressed in a steady migration from the villages.

The object of this measure was to help the deserving labouring man to acquire a small holding, that is to say, a portion of land not less than one acre or more than fifty acres in extent and of an annual value not exceeding £50. It is not necessary here to describe the legal steps by which this was to be accomplished. The essence of the bargain was that a fifth of the purchase money should be paid down, and the remainder in half-yearly instalments spread over a period not exceeding fifty years. But if the local authority thought fit a portion of the purchase money, not exceeding one-fourth, might remain unpaid, and be secured by a perpetual rent charge upon the holding. It cannot be said that this Act has attained the object for which it was drawn up. From a return made to the House of Commons in February 1898 we obtain a statement of the working of the Allotments and Small Holdings Acts between the 27th December 1894 and the 24th of June 1897. Of this document the following is a summary.

Land was acquired for allotments between the 27th December 1894 and 24th of June 1897 by—

3 county councils: (*a*) in two cases by purchase by agreement, the land handed to parish councils to manage; (*b*) in one case hiring by agreement. Total acreage, 33 acres 38 poles—let to forty-five tenants.

3 councils of county boroughs: one case of purchase, three of hiring by agreement. Total acreage, 42 acres 2 roods 23 poles—let to 171 tenants.

120 urban district councils: (*a*) in 17 cases purchase by agreement; (*b*) in 118 cases hiring by agreement. Total acreage, 1591 acres 2 roods 4 poles—let to 6644 tenants.

9 rural district councils: four cases by purchase, seven by hire. Total acreage, 160 acres 2 roods 18 poles—let to 288 tenants.

1009 parish councils: (*a*) in six cases by compulsory hiring; (*b*) in 1022 cases by hiring by agreement. Total acreage, 12,967 acres 2 roods 24 poles—let to 24,389 tenants.

4 parish meetings: by hiring by agreement. Total acreage, 19 acres 17 poles—let to 47 tenants.

1 metropolitan vestry: by hiring by agreement. 4 acres 2 roods 12 poles—let to 79 tenants.

In this period, therefore, local authorities have acquired for allotment 14,818 acres—let to 31,663 tenants; but 61 county councils, 61 councils of county boroughs, 963 urban district councils, 692 rural district councils, 6361 parish councils, and 5733 parish meetings had not acquired land for allotment.

These facts are not highly encouraging to those who would wish to see every workman in possession of an allotment; but the results of the Small Holdings Act are trivial in comparison. Within the same period only three county councils had acquired land in six parishes for small holdings; in one it was by purchase, in the other five by hire, and the total acreage amounted to only 120 acres 3 roods 5 poles—let to 45 tenants.

It is, however, an English characteristic to prefer private to public arrangements, and probably a very great majority of the allotments now being cultivated are due to individual initiative. There are no means of arriving at the actual facts, but data exist whereby it is at least possible to form some rough idea of them. It is not the custom to give in the annual agricultural returns any statement of the manner in which land is held, and the latest information is to be found in the returns presented to Parliament in 1895. From these we get the following table, which will enable the reader to compare the numbers of large and small holdings, and understand how land is held:—

	From 1 to 5 Acres.		From 5 to 50 Acres.		Above 50 Acres.	
	No.	Acreage.	No.	Acreage.	No.	Acreage.
England . .	87,065	265,268	170,591	3,288,669	122,533	21,290,751
Wales . . .	10,768	25,633	30,969	685,024	18,556	2,167,702
Scotland . .	20,150	65,891	33,921	608,930	25,568	4,219,645
Great Britain	117,983	356,792	235,481	4,582,623	166,657	27,678,098

It would appear from this that, whereas 27½ million acres are held in large holdings, scarcely five million acres are in small holdings. The proportion varies greatly according to the district. Some counties, such as Cheshire and Worcester, are rich in small holdings; while others—Westmoreland and Devonshire, for example—contain few. We may assume, however, that the allotments do not come into the table at all. They are separately tabulated as holdings of land not exceeding an acre in extent. They may be summarized as follows:—

	Under 1 Acre.	Of 1 Acre.	Total of 1 Acre and over.
England . .	522,163	34,459	556,622
Wales . . .	12,179	1,095	13,274
Scotland . .	7,648	1,589	9,237
Great Britain	541,990	37,143	579,133

These figures are useful, but they should be taken as only approximate. It is in the nature of the case that there should be much fluctuation in the number of these tiny plots, movement of population and other causes frequently leading to whole nests of them being deserted by the original occupiers and turned into ordinary fields again. A large proportion of them are held by persons not engaged in agriculture, but following other pursuits: witness the fact that they are most numerous in proportion to every 1000 acres cultivated in Nottingham, Northampton, and Leicester. Very often an allotment is more acceptable to a village tradesman, a carpenter, bootmaker, or miner, than to a farm-servant. Work on it to the latter represents only a continuation of the day's drudgery, while it is a pleasant change and relief to the former. Further, local conditions have much to do with their popularity. In practice, it is not found that a Northumbrian hind cares much for an allotment. He has a thousand or fifteen hundred yards of potatoes grown with his master's crop, and he gets meal and fuel as part of his wages. Better still, he has a twelve months' engagement for "rain or shine, sickness or health"; but where perquisites are not given on a scale so liberal, and wages are lower and engagements from week to week—even from day to day, as in some of the eastern counties of England,—then naturally the advantages of the allotment are much more highly prized.

Apart from those created by legislation, there are many groups of small agricultural holdings that have either come to exist naturally or have been made during the last few years. Cheshire is a county wherein the former prevail. A typical estate in it is that of Lord Egerton of Tatton. This is divided into 189 holdings, of which 117 are of less than 50 acres and 72 are under 10 acres. Even in a county so notable for its excellent pasture a man could scarcely manage to live on one of these last-mentioned holdings; and, as a matter of fact, those who have them are either agricultural labourers or possess some other means of earning a livelihood; but the land forms a valuable supplement to wages. One point of importance is that nowhere are large healthy families more prized than on these small holdings, where the girls at a very early age learn to look after the poultry and attend to the lighter duties, while boys are set to harder tasks. It has been observed that in portions of England where farm labour is badly paid, and the men have no land, children are regarded as burdens and misfortunes. The Peckforton estate of Lord Tollemache differs from that of Lord Egerton, inasmuch as pains have been taken to make small holdings on it. There are over 250 cottages, to which as much land is attached as enables the occupier to keep a cow, and the sale of milk and butter brings in enough to pay the rent and vastly improve the food supply of the cottage. As there are over 120,000 holdings of less than 50 acres in Cheshire, it will be understood that the estates mentioned are typical of others. The Isle of Axholm, in Lincolnshire, has long been famous for its small holdings, and as they are to a great extent cultivated on the open-field system they are probably of great antiquity. In the parish of Epworth there are 421 agricultural holdings, of which 356 are under and 65 over 20 acres in extent; in the parish of Haxey, 574 agricultural holdings, 475 under and 99 over 20 acres; in West Butterwick, 132 agricultural holdings, 109 under 20 acres and 23 over. It would appear that the tendency is towards subdivision. Most of the land is held in strips, and at the owner's death these are often sold separately. During the worst of the depression a great amount of suffering was felt, but recently accounts have been more cheerful. Lord Savile's estate in Yorkshire is an outstanding example of land in small holdings. It consists of 10,848 acres, held in 682 tenancies, averaging about 16 acres each. Experience there seems to show that a man requires about 30 acres of ordinary agricultural land in order to obtain a living from it.

To these examples of small holdings, it may be useful to add an account of the manner in which one set was formed; and we select for the purpose that at Winterslow, in Wiltshire, chiefly for the reason that, save for a little guidance, the men worked out their own salvation. Major Poore, who originally conceived the idea, has not been a penny out of pocket on account of it. When land was cheap in 1892, owing to the depression in agriculture, he purchased an estate. The price came to an average of £10 an acre, and he made the average for selling it out again £15 on a principle of instalments. But his object was not to make any profit from the transaction, and he formed what is termed a Landholders' Court, formed of the men themselves, every ten choosing one to represent them. This court was found to act well. It collected the instalments, which are paid in advance; and of course the members of it, down to the minutest detail, knew not only the circumstances, but the character of every applicant for land. The result speaks for itself. Early in 1901 there were no arrears, and the expenses having proved only trivial there was a balance of £666 in favour of the court, and about £150 had been spent in sinking a well. This fund has the very great advantage of establishing a common interest in the holders and inducing them to stick together. Various sums have been lent out on mortgage, and, were a neighbouring village to wish it, the Winterslow holders are prepared to listen to an application for a loan. It should be added that all the owners are, in the true sense of the word, peasants. They do not depend on the land for a living, but work in various callings—many being woodmen—for wages that average about 15s. a week. The holdings vary in size from less than an acre to ten acres, and are technically held on a lease of 1999 years, practically freehold, though by the adoption of a leasehold form a saving was effected in the cost of transfer. On the holdings most of the men have erected houses, using for the purpose chalk dug up from their gardens, it lying only a few inches below the surface. It is not rock, but soft chalk, so that they are practically mud walls; but being as a rule at least 18 inches thick, the houses are very cool in summer and warm in winter. Major Poore calculates that in seven years these poor people—there are not thirty of them altogether—have managed to produce for their houses and land a gross sum of not less than £5000. This he attributes to the loyal manner in which even distant members of the family have helped.

It remains to give a brief outline of what small holdings are like outside Great Britain. From the results of the Belgian Agricultural Inquiry of 1895 the following table has been compiled, assuming that one hectare = 2½ acres:—

Size of Holding.	Occupied by Owner.		Occupied by Tenant.		Total.
	Whole.	More than half.	More than half.	Whole.	
	No.	No.	No.	No.	No.
1¼ acres and under .	100,169	8,759	34,779	305,413	458,120
1¼ " " 5 acres	27,895	19,544	58,829	70,465	176,233
5 " " 10 "	12,669	13,873	30,340	25,006	81,308
10 " " 50 "	16,690	18,909	33,443	28,387	97,429
50 or 100 acres . .	2,021	1,497	3,315	4,517	11,350
Over 100 "	903	470	1,417	2,395	5,185
Total . . .	166,267	63,052	162,123	436,183	829,625

It will be seen from this table that Belgium is preeminently a country of small holdings, more than half of the total number being under 50 acres in extent. Of course it is largely a country of market gardens; but as the holdings are most numerous in Brabant, East and West Flanders, and Hainault, the provinces showing the largest number of milch cows, it would seem that dairying and *la petite culture* go together.

In Germany, the number of small holdings is proportionately much larger than in Great Britain. The returns collected in 1895 showed that there were 3,235,169, or 58·22 per cent. of the total number of holdings under 5 acres in area; and of these no fewer than 11 per cent. are held by servants as part of their wages. A table compiled for the *Journal of the Board of Agriculture* enables us to compare the other holdings with those of Great Britain:—

Size of Holdings.	Germany.		Great Britain.	
	Number.	Per cent.	Number.	Per cent.
5 to 50 acres	2,014,940	86·8	235,481	58·6
50 to 500 „	292,982	12·6	161,438	40·1
Over 500 „	13,809	0·6	5,219	1·3
Total . .	2,321,731	100	402,138	100

Great Britain, it will be seen, has over 40 per cent. of large farms of between 50 and 500 acres as compared with Germany's 12·6, while the latter has 86·8 of small holdings, compared with England's 58·6.

France also has a far larger proportion of small holdings than Great Britain; its cultivated area of 85,759,000 acres being divided into 5,618,000 separate holdings, of which the size averages a little over 15 acres as against 63 in Great Britain. Of the whole number, 4,190,795 are farmed by the owners, 934,338 are in métayage, and 1,078,184 by tenants. The leading feature is the peasant proprietary. Half of the arable, more than half of the pasture, six-sevenths of the vineyards, and two-thirds of the garden lands are farmed by their owners. Comparison with Great Britain is difficult; but it would appear that, whereas only 11 per cent. of British 520,000 agricultural holdings are farmed by the owners, the proportion in France is 75 per cent. A further point to be noted is that the average agricultural tenancy in France is just one-fourth of what it is in Great Britain, and the average owner-farmed estate only one-sixth.

Those interested in the formation of small holdings in Great Britain will find much to interest them in the history of Danish legislation. British policy for many generations was to preserve demesne land, and there are many devices for insuring that a spendthrift life-owner shall not be able to scatter the family inheritance; but as long ago as 1769 the Danish legislators set an exactly opposite example. They enacted that peasant land should not be incorporated or worked with estate land; it must always remain in the ownership and occupation of peasants. In this spirit all subsequent legislation was conceived, and the allotment law that came into force in October 1899 bears some resemblance to the English Small Holdings Act of 1892. It provides that labourers able to satisfy certain conditions as to character may obtain from the state a loan equal to nine-tenths of the purchase-money of the land they wish to acquire. This land should be from 5 to 7 acres in extent and of medium quality, but the limits are from 2¾ to 10¾ acres in the case of better or poorer land. The total value should not exceed 4000 kr. (£222). The interest payable on the loan received from the state is 3 per cent. The loan itself is repayable after the first five years by annual instalments of 4 per cent. until half is paid off; the remainder by instalments of 3½ per cent., including interest. Provision is, however, made for cases where the borrower desired to pay off the loan in larger sums. Regulations are laid down regarding the transfer of such properties and also their testamentary disposition. The Treasury was empowered to devote a sum of 2,000,000 kroners (£111,000) to this purpose for five years; after that the land is subject to revision.

Even before this law was passed Denmark was a country of small holdings, the peasant farms amounting to 66 per cent. of the whole, and the number is bound to increase, since the incorporation of farms is illegal, while there is no obstacle to their division. Between 1835 and 1885, the number of small holdings of less than one töndekarthorn increased from 24,800 to 92,856. What gives point to these remarks is, that Denmark seems in the way to arrest its rural exodus, and was one of the first countries to escape from the agricultural depression due to the extraordinary fall in grain prices.

AUTHORITIES.—WALTER OF HENLEY'S *Husbandry*.—*The English Village Community*, by FREDERIC SEEBOHM.—*Annals of Agriculture*, by ARTHUR YOUNG.—*The Agricultural Labourer*, by T. E. KEBBEL.—*Report on the Employment of Women and Children in Agriculture*, 1867 (historical sketch by Messrs TREMENHEERE and TUFNALL).—*A Study of Small Holdings*, by W. E. BEAR.—*The Law and the Labourer*, by C. W. STUBBS.—"Agricultural Holdings in England and Abroad," by Major CRAIGIE (*Statistical Society's Journal*, vol. l.) (P. A. G.)

Alloys.—The derivation of this word is very clear. The old French *alei*, which was retained in the Norman as *allai* or *alai*, comes from *alleium* or *alaium*, the original being probably *ad-ligo* (*alligo*), to bind together. In the modern sense it would be difficult to find a better description of the nature of an alloy than that given by the metallurgist Biringuccio in 1540, who says that an alloy only signifies an intimate association of one metal with another.

Metals and non-metals.

From a modern point of view the question immediately arises whether the associations of metallic elements give results which are in any way different from the union of a metal with a non-metal. Though the whole tendency of modern work has been to break down the barrier between metals and non-metals, still in some ways alloys appear to present a special case of union. Metallic vapours are miscible with any other gas, but metals and non-metals do not seem to unite to form a liquid or solid solution. Nor, it should be remembered, do all metals mix and form a solid mass which is uniform in composition. It has been held that there is no non-metallic solvent for a metal which acts without recognizable chemical action, or one from which the pure metal can be obtained by crystallization. Metallic compounds will, however, dissolve readily in metals; thus, cuprous oxide dissolves in metallic copper. Metallic sulphides again will dissolve in metals, *e.g.*, silver sulphide in lead, and lead in sulphide of lead, and the sulphides will crystallize out from the metallic solvent. In this way bismuth sulphide crystallizes from bismuth. The solubility of carbon in iron, and its separation as graphite from the solvent, is a fact of great industrial importance. It is also considered that no isomorphous mixture of a metallic and a non-metallic substance is known. The molecular structure of a metal appears, therefore, to present some differences from that of a non-metal. Metals possess a characteristic property of conducting electricity without an attendant transfer of matter. This is known as metallic conduction. It has been shown that the diffusion of one metal into another can take place in solid metals at comparatively low temperatures, that is, at temperatures which are far below the melting-points, either of the metals undergoing diffusion, or of the alloys which result from their union. In comparatively recent years a large amount of attention has been devoted to the investigation of the properties and constitution of alloys.

Formation.

In ordinary cases the constituent metals of alloys are united by melting them together and stirring the molten mass. The action is, however, far from being a simple one, as the union is not merely due to the mechanical stirring, but to the fact that the metals dissolved in each other become spread uniformly by true diffusion. In some cases, the constituent metals of an alloy which are miscible when fluid, separate if the fluid mass is allowed to rest, while in other cases partial separation occurs even after the bulk of the mass has become solid. It sometimes happens that metals will unite at temperatures which are far below those required to fuse them; to the union so effected the term *cementation* is applied. A very interesting observation was made in 1820 by Faraday and Stodart, who in the course of an investigation on the alloys of iron with other metals, note their failure to produce certain alloys by cementation, but consider it "remarkable" that platinum will unite with steel at a temperature at which the steel is still solid. This early recognition of the fact that alloys can be produced by cementation is very curious, and shows that Faraday and Stodart had observed a creeping molecular action to occur at a temperature below the fusing-point of either platinum or carburized iron. So long ago as 1878 W. Spring showed that under a pressure varying from 13 to 47 tons per square inch, metallic filings will unite into solid masses which under pressure behave like fluids and truly flow through the apertures of the receptacle in which they are compressed. This fact lends support to the view that cohesion is a form of chemical affinity. By compressing, in a finely divided state, 15 parts of bismuth, 8 parts of lead, 4 parts of tin, and 3 parts of cadmium, an alloy is produced which fuses at 100° C. Hallock found that metals might be united without pressure, if they were heated to the melting-point of the alloy to be formed, that is, to a point which as a rule is much below the melting-point of the least fusible constituent.

It has long been known that brass may be formed by electro-deposition from a solution containing copper and zinc. In this connexion J. B. Senderens has made a very interesting series of experiments on the precipitation of one metal from solution by another metal. He points out that Richter in his researches, published between the years 1796-99, was led to the promulgation of the law which is now expressed as follows: "Metals are precipitated from their saline solution atom for atom of the same valency." Senderens shows that this is not rigorously accurate, since the amount of the precipitating metal is always in excess. Thus, in the well-known reaction employed in refineries for the precipitation by copper of silver from sulphate solutions, in accordance with the equation—$AgSO_4 + Cu = Ag + CuSO_4$, if the solution of sulphate of silver contains 4·5 grammes of the salt in a litre of water, a plate of copper immersed in it for seven days will be found to have lost 0·012 gramme more than theory demands. Senderens shows that this fact is of singular interest in relation to the allotropy of iron, but his work is quoted here on account of its bearing on the formation of alloys in the "wet way." Several chemists, among whom Planché and Brugnatelli may be specially mentioned, have thought that alloys might be so prepared, while Gay-Lussac at first favoured that opinion, but abandoned it later. So long ago as 1857, in a remarkable paper on "The Reciprocal Precipitation of Metals," Odling showed that a piece of copper coated with cadmium, and a coil of copper and cadmium foils rolled up together, behave very differently when treated with hydrochloric acid, the metallic deposit of cadmium partaking of the character of an alloy. Such precipitation of one metal on another he attributes to the affinity of one metal for the other. He in fact formed alloys in the "wet way." More recently Mylius and Fromm have shown that alloys may be precipitated from dilute solutions by zinc, cadmium, tin, lead, and copper. Thus a strip of zinc plunged in a solution of sulphate of silver containing not more than 0·03 gramme of silver in the litre, becomes covered with a flocculent precipitate which is a true alloy of silver and zinc, and in the same way, when copper is precipitated from its sulphate by zinc, the alloy formed is brass. They have also formed certain alloys of definite composition such as $AuCd_3$, Cu_2Cd, and, more interesting still, Cu_3Sn. If volatile metals in the form of vapour are brought in contact with non-volatile metals union will in many cases ensue. It has been shown that alloys of platinum and palladium with cadmium, zinc, and magnesium may be so produced.

Alloys as solid solutions.

In the classical monograph on alloys published by Matthiessen in 1860 (*Phil. Trans. R. S.*), it was clearly stated that alloys must be considered to be solidified solutions. Few generalizations have been more fruitful in results, and much modern work has been devoted to the development of the view. The constitution of solutions has been very closely studied in recent years, and from the point of view of their freezing-points F. Guthrie has shown that solutions of metals in each other behave like ordinary aqueous solutions of salts. His actual results for solutions of common salt in water are given in Fig. 1. If, for instance, a thermometer be placed in a 10 per cent. solution of salt in water which is being slowly cooled by means of an external freezing mixture, the mercury will halt in its fall at about 8° C., owing to the separation of pure salt-free ice. This gives the point *d* on the branch AB. The mercury then continues to fall until the temperature of 22° C. is reached, and the cryo-hydrate or *eutectic* of ice and salt solidifies. This eutectic, as has been abundantly shown, consists merely of a very intimate mixture of ice and salt in juxtaposition. As the degree of concentration of salt in the original solution increases, the initial freezing-point on the branch AB will become lower and lower, while the second freezing point always remains constant at − 22° C.; and when the solution contains 23·5 per cent. of salt, both freezing-points coincide in the point B at − 22° C. The salt branch of the diagram is a very steep one, because the melting-point of pure salt is above 700° C. Take on this branch a point *e* representing water containing more salt than 23·5 per cent., say 25 per cent. In this case the first solid to separate on cooling is pure salt, and it does so at − 12° C, which, for this degree of concentration is the first halting stage of the thermometer; the second is, as before, the solidification of the eutectic of salt and ice, which always has the same composition, and freezes at the same temperature, namely 22° C. The diagram therefore has two branches joining at B a horizontal line. This curve has been described at some length, because curves representing the freezing-points of any series of alloys may be derived in the same way. Guthrie considered that alloys in cooling behave like a cooling mass of clear molten granite. This would throw off in cooling "atomically definite" bodies, leaving behind a fluid mass not definite in composition, since the quartz and felspar undergo solidification before the mica. In alloys much the same thing happens, for when a molten mass of lead and bismuth, or bismuth and tin, cools, a certain alloy of the metal falls out, just as the quartz and felspar did, and ultimately the most fusible alloy of the series is left. This is called by Guthrie the eutectic alloy, but the proportions between the constituent metals are not atomic, and Guthrie pointed out that "the preconceived notion that the alloy of minimum temperature of fusion must have its constituents in simple atomic proportions, and that it must be a chemical compound, seems to have misled previous investigators"; but he adds "that certain metals may and do unite with one another in the small multiple of their combining weights, may be conceded; the constitution of eutectic alloys is not in the ratio of any simple multiple of their chemical equivalents, but their composition is not on that account less fixed, nor are their properties the less definite." The constitution of eutectic alloys as revealed by the microscope will be dealt with in the article on METALLOGRAPHY.

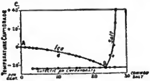


Fig. 1.

Mendeléeff regards solutions as strictly definite atomic chemical combinations at temperatures higher than their dissociation temperatures. Definite chemical substances may be either formed or decomposed at temperatures which are higher than those at which dissociation begins; the same phenomenon occurs in solutions. In order to show how close the relation is between freezing solutions of salt in water and in an alloy, no simpler case could well be taken than the lead-tin series given in Fig. 2. It represents, moreover, a series in which the freezing-points are well within range of the ordinary mercurial thermometer, and of which the complete freezing-point curve is exactly of the same order as that which represents the freezing of a solution of salt, as Roberts-Austen has shown. For alloys of which the melting-points are beyond the range of the ordinary mercurial thermometer, some form of pyrometer must be employed. Heycock and Neville, in a very elaborate and prolonged series of investigations on the freezing-point curves of alloys, have used the platinum resistance pyrometer, and they determine the points at which alloys solidify or metallic constituents fall out of solution by noting the points at which the electrical resistance (as measured by a Wheatstone Bridge) remains constant. Roberts-Austen, on the other hand, has devised a recording pyrometer for use with a thermo-junction. This instrument traces autographically on a sensitized plate the cooling curve of any definite alloy, the halting places corresponding to the arrests in the fall of the mercurial column in an ordinary thermometer being indicated by more or less horizontal portions. H. le Chatelier has thrown much light on the question of the fusibility of alloys. He points out that in considering them as solutions it is necessary to modify the view in which ordinary solutions are regarded. In ordinary chemical language, it is usual to distinguish the solvent from the body which is dissolved, but really the two bodies play the same part. Many aqueous solutions, as he shows, can exist below the freezing-point of water: that of chloride of calcium, for instance, which is liquid down to − 55° C. He demonstrates that the typical curves which represent the fusibility of alloys have in each case corresponding curves in saline solutions, and in confirmation quotes experiments by Loewel and Bakhuis-Roozeboom, together with his own results, especially referring to the freezing-point curves of isomorphous mixtures of certain organic substances first recorded by Kuster. The result of Le Chatelier's very interesting work is the division of the freezing-point curves of alloys into the following classes:—In the first the metals dissolving each other give neither definite compounds nor isomorphous mixtures. The curves of this class consist of two branches as is shown by the lead-tin curve in Fig. 2, in which composition and temperature are co-ordinates, and it would appear that when a curve is composed of two branches only it is safe to conclude that after solidification the two isolated metals are simply in juxtaposition. In the second case, the two metals give rise to one or more definite compounds. Here, as in the case of a solution of sulphate of soda in water, one branch of the curve is peculiar and characteristic. If the compound which is formed between the two metals fuses without dissociation, there will be a maximum point in the curve which corresponds to the definite compound, and the curve will be of the form shown by Roberts-Austen's gold-aluminium curve in Fig. 3. H. le Chatelier has found similar curves for the copper-tin alloys. In the case of the aluminium-gold series the maximum point occurs, as Fig. 3 shows, at the alloy $AuAl_2$ the freezing-point of which is higher than that of pure gold itself. If the compound formed in the alloy is dissociated, the portion of the curve which marks its presence will be rounded. With regard to the gold-aluminium series, Heycock and Neville have shown that it presents a very complicated case, as not merely one compound ($AuAl_2$), but several compounds of gold and aluminium are formed. In the third case, the two metals which are dissolved in each other form isomorphous mixtures. In this group the freezing-points of the alloys of the series lie on a straight line, Fig. 4, as do the silver-gold alloys examined by Schertel. This question is very important, and Gautier has given several instances of such isomorphous alloys, among which that of antimony and bismuth may be cited.

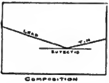


Fig. 2.

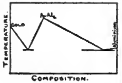


Fig. 3.

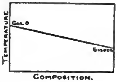


Fig. 4.

Surfusion.

Metals do not appear to have been studied from the point of view of surfusion until 1880, when A. D. van Riemsdijk showed that gold and silver would both pass below their actual freezing-points without becoming solid. Roberts-Austen pointed out that surfusion might be easily measured in metals and in alloys by the sensitive method of recording pyrometry to which reference has already been made. He also showed that the crossing of curves of solubility which had already been observed by H. le Chatelier and by Dahms in the case of salts could also be measured in the lead-tin alloys (Fig. 2). The investigation of the mutual relations of partially miscible liquids due to Alexejew, Konovalow, and to Duclaux was extended to alloys by Alder Wright. The addition of a third metal will sometimes render the mixture of two other metals homogeneous. Heycock and Neville proved that when one metal is alloyed with a small quantity of some other metal the solidification obeys the law of Raoult. They also showed that the molecule of a metal when in dilute solution often consists of one atom. There are, however, numerous exceptions to this rule. In the case of aluminium dissolved in tin and mercury or bismuth in lead, it is at least probable that the molecules in solution are Al_2, Hg_2, and Bi_2 respectively, while tin in lead appears to form a molecule of the type Sn_4.

Electrical conductivity.

Matthiessen in the paper already referred to showed that the electrical conductivity of all alloys may be represented graphically by three types of curves. Gold and silver alloyed afford an instance of the first of these types, there being a rapid decrease in the conductivity (or increase in the resistance) when either silver is added to gold or gold to silver. The tin-copper alloys are, as regards electrical conductivity, types of the L-shaped curve. There is a rapid diminution of conductivity when tin is added to copper, and at a certain point there is an abrupt bend, and the curve proceeds more or less horizontally. More recent work has, however, shown that there are certain breaks where the definite compounds $SnCu_3$ and $SnCu_4$ occur. The conductivities of tin and lead are both low, and the lead-tin series is represented by a straight line connecting the two metals. The conductivity curve of these alloyed metals represents the third type. For the details reference must be made to Matthiessen's memoir. At low temperatures, Dewar and Fleming have shown that the conductivity of pure metals increases greatly as the temperature is diminished. Gold, in the purification of which elaborate precautions were taken, appears to present a very good instance. On the other hand, the conductivity of alloys does not increase with diminution of temperature in the same manner, and a marked contrast between the behaviour of metals and alloys is thus presented. Rayleigh has pointed out that this difference may arise from the heterogeneity of alloys. When a current is passed through an alloy, a series of Peltier affects, proportional to the current, are set up between the particles of the different metals, and these create an opposing electromotive force which is indistinguishable experimentally from a resistance. If the alloy were a true chemical compound the counteracting electromotive force should not occur, and experiments in this direction are much needed. Roberts-Austen has shown that in the case of molten alloys the conduction of electricity is apparently metallic, no transfer of matter attending the passage of the current. A group of bodies may, however, be yet discovered between alloys and electrolytes in which evidence may be found of some gradual change from wholly metallic to electrolytic conduction. Laurie has determined the electromotive force of a series of copper-zinc, copper-tin, and gold-tin alloys, and as the result of his experiments he points to the existence of definite compounds. Explosive alloys have been formed by Deville and Debray in the case of rhodium, iridium, and ruthenium, which evolve heat when they are dissolved in zinc. When the solution of the rhodium-zinc alloy is treated with hydrochloric acid, a residue is left which undergoes a change with explosive violence if it be heated *in vacuo* to 400°. The alloy is then insoluble in "aqua regia." The metals have therefore passed into an insoluble form by a comparatively slight elevation of temperature.

Industrial applications.

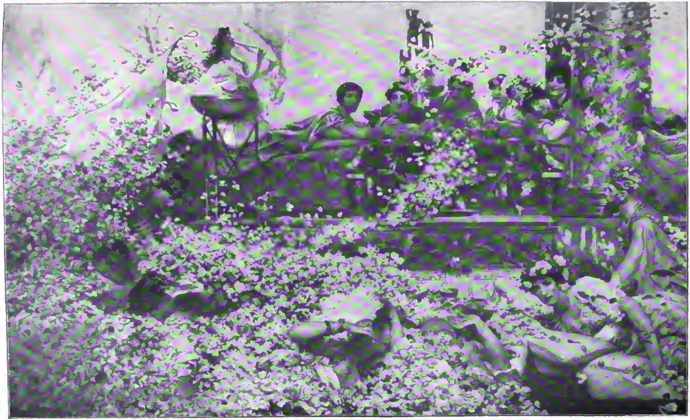
The feature of the period from 1875 to 1901 has been the increased attention which has been devoted to the applications of the rarer metals. Thus nickel, which was formerly used in the manufacture of "German silver" as a substitute for silver, is now widely employed in naval construction, and in the manufacture of steel armour-plate, projectiles, and, when alloyed with copper, the envelopes of bullets. Manganese not only forms with iron several alloys of great interest, but alloyed with copper is used for electrical purposes. Chromium also, in comparatively small quantities, is taking its place as a constituent of steel axles and tyres, and in the manufacture of tool-steel. Vanadium, molybdenum, and titanium may be expected soon to play an important part in the constitution of steel. Titanium is alloyed in small quantities with aluminium for use in naval architecture. The importance is now widely recognized of considering the mechanical properties of alloys in connexion with the freezing-point curves to which reference has already been made, but the subject is a very complicated one, and all that need be said here is that when considered in relation to their melting-points the pure metals are consistently weaker than alloys. The presence in an alloy of a eutectic which solidifies at a much lower temperature than the main mass, implies a great reduction in tenacity, especially if it is to be used above the ordinary temperature as in the case of pipes conveying super-heated steam. It may also be stated that alloys of metals with similar melting-points have higher tenacity when the atomic volumes of the constituent metals differ than when they are nearly the same.

For further information the reader may refer to:—ROBERTS-AUSTEN. Reports i. to vi. to the *Alloys Research Committee of the Institution of Mechanical Engineers*, London, 1891 to 1899; *Introduction to Study of Metallurgy*, London, 1898 (see section devoted to Alloys for references to foreign papers).—*Cantor Lectures on Alloys delivered at the Society of Arts*, 1884-1901.—HEYCOCK and NEVILLE. Various papers *Transactions of the Royal Society* and *Journal of the Chemical Society*, 1890 to the present time.—OSMOND, LE CHATELIER, CHARPY, and Others. *Bull. soc. de l'encouragement pour l'industrie nationale*, Paris (various papers 1880 to present year, especially last ten years).—ROBERTS-AUSTEN and STANSFIELD. "La constitution des alliages métalliques," *Report of the Physical Congress*, Paris, 1900, vol. i. Gauthier Villars, Paris.—W. SPRING. *Bull. de l'acad. roy. de Belgique*, 1878 to recent years.—R. H. THURSTON. *Materials of Engineering.* Wiley, New York. (W. C. R.-A.)

Allport, Sir James Joseph (1811-1892), English railway manager, born 27th February 1811, was a son of William Allport, of Birmingham, and was associated with railways from an early period of his life. In 1843 he became general manager of the Birmingham and Derby Railway, and in the following year succeeded to the same position on the Newcastle and Darlington line. Six years later he assumed the charge of the Manchester, Sheffield, and Lincolnshire (now the Great Central) Railway, and finally, in 1853, was appointed to the general managership of the Midland Railway—an office which he held continuously, with the exception of a few years between 1857 and 1860, until his retirement in 1880, when he became a director. During these twenty-seven years the Midland grew to be one of the most important railway systems in England, partly by the absorption of smaller lines and partly by the construction of two main extensions—on the south to London and on the north to Carlisle—whereby it obtained an independent through-route between the metropolis and the north. In the railway world Sir James Allport was known as a keen tactician and a vigorous fighter, and he should be remembered as the pioneer of cheap and comfortable railway travelling. He was the first to appreciate the importance of the third-class passenger as a source of revenue, and accordingly, in 1872, he inaugurated the policy—subsequently adopted more or less completely by all the railways of Great Britain—of carrying third-class passengers in well-fitted carriages at the uniform rate of one penny a mile on all trains, even the fastest. The diminution in the receipts from second-class passengers, which was one of the results, was regarded by some authorities as a sign of the unwisdom of his action, but to him it appeared a sufficient reason for the abolition of second-class carriages, which therefore disappeared from the Midland system in 1875, the first-class fares being at the same time substantially reduced. This innovation too has been followed by other companies, though not with the same unanimity as attended his earlier reform. He was also the first to introduce the Pullman car on British railways. Allport received the honour of knighthood in 1884. He died in London on 25th April 1892. (H. M. R.)

Almada, a town of Portugal, district Lisbon, on the left bank of the Tagus, immediately opposite Lisbon, with manufactories of cork. It was founded by English crusaders in the reign of Affonso Henriques. Population about 7000.

Almaden, or ALMADEN DEL AZOGUE, a town of Spain, in the province of Ciudad Real, in the Sierra Moreno. In the latter part of the 19th century the Almaden quicksilver mines were leased by the state to the house of Rothschild, whose contract expired in 1900, but who still sell the quicksilver for the Spanish Government. The town has a good hospital, schools, and other buildings. Care is taken to minimize the effects of the fumes on the operatives, whose health is very rapidly and seriously impaired. Hence the custom formerly was to use convicts for the labour in the quicksilver mines. Owing to the deleterious effects of the atmosphere, exemption from military service is granted to men who have been two years employed in the quicksilver mines. The average output of mercury is 10 per cent. on the ore extracted, and, according to official returns, 75 per cent. of the value of the output is clear profit. In 1898 there were 1906 men and 417 lads employed in the mines. The amount of ore extracted was 19,945 tons, from which 1595 tons of quicksilver were drawn, being 46,211 flasks weigh-



"The Roses of Heliogabalus." By Sir L. Alma-Tadema, R.A.

(Reproduced by permission of Sir John Aird, Bart., M.P.)

ing 55,000 ℔. In the Arrayanes sulphurous and lead mines 930 men, 18 women and 35 lads were employed, and 18,962 tons of ore were extracted in 1898. The Almaden concession covers over 490,872 acres; the Arrayanes only 1397 acres. Population, 7388.

Alma-Tadema, Sir Laurence (or **Laurens**), British artist, was born on the 8th of January 1836, at Dronryp, a Friesian village near Leeuwarden, the son of Pieter Tadema, a notary, who died when he was four years old. Alma was the name of his godfather. His mother (d. 1863) was his father's second wife, and was left with a large family. It was designed that he should follow his father's profession; but he had so great a leaning towards art that, after a long struggle between duty and inclination, during which his health broke down, he was sent to Antwerp, where in 1852 he entered the academy under Gustav Wappers, the leader of that romantic movement in Belgian art which was fast obliterating the old classical school of David. Thence he passed to the *atelier* of Henri (soon afterwards to become Baron) Leys. In 1859 he assisted Leys in his frescoes in the hall of the Hôtel de Ville at Antwerp. In the exhibition of his collected works at the Grosvenor Gallery in London in the winter of 1882-83 were two pictures which may be said to mark the beginning and end of his first period. These were a portrait of himself, dated 1852, and "A Bargain," painted in 1860. His first great success was a picture of "The Education of the Children of Clovis" (1861), which was exhibited at Antwerp. In the following year he received his first gold medal at Amsterdam. The "Education of the Children of Clovis" (three young children of Clovis and Clotilde practising the art of hurling the axe in the presence of their widowed mother, who is training them to avenge the murder of their own parent) was one of a series of Merovingian pictures, of which the finest was the "Fredegonda" of 1878 (exhibited in 1880), where the dejected wife or mistress is watching from behind her curtain window the marriage of Chilperic I. with Galeswintha. It is perhaps in this series that we find the painter moved by the deepest feeling and the strongest spirit of romance. One of the most passionate of all is "Fredegonda at the Death-bed of Prætextatus," in which the bishop, who has been stabbed by order of the queen, is cursing her from his dying bed. Another distinct series attempts to reproduce the life of ancient Egypt. One of the first of these was called "Egyptians 3000 Years Ago," and was painted in 1863. A profound depth of pathos is sounded in "The Death of the Firstborn," painted in 1873. Among his other notable Egyptian pictures are "An Egyptian at his Doorway" (1865), "The Mummy" (1867) (depicting the family of the defunct bringing offerings to a mummy which stands on end at the right of the spectator), "The Chamberlain of Sesostris" (1869), "A Widow" (1873), and "Joseph, Overseer of Pharaoh's Granaries" (1874). On these scenes from Frankish and Egyptian life Alma-Tadema spent great energy and research; but his strongest art-impulse was towards the presentation of the life of ancient Greece and Rome, especially the latter. Amongst the best known of his earlier pictures of scenes from classical times are "Tarquinius Superbus" (1867), "Phidias and the Elgin Marbles" (1868), and "The Pyrrhic Dance" and "The Wine Shop" (1869). "The Pyrrhic Dance," though one of the simplest of his compositions, stands out distinctly from them all by reason of its striking movement. "Phidias and the Elgin Marbles" is the first of those glimpses of the art-life of classical times, of which "Hadrian in England," "The Sculpture Gallery," and "The Picture Gallery" are later examples. "The Wine Shop" is one of his many pictures of historical *genre*, but marked with a more robust humour than usual. In 1863 Alma-Tadema married a French lady, with whom he lived at Brussels till 1869, when she died, leaving him a widower with two daughters, both of whom have since made reputations—one in art, the other in literature. In 1869 he sent from Brussels to the Royal Academy two pictures "Un amateur Romain" and "Une danse Pyrrhique," which were followed by three pictures, including "Un Jongleur," in 1870, when he came to London. By this time, besides the distinctions he gained in Holland and Belgium, he had been awarded medals at the Paris Salon of 1864 and the Exposition Universelle of 1867. In 1871 he married an English lady, Miss Laura Epps, who, under her married name, has also won a high reputation as an artist. After his arrival in England Alma-Tadema's career was one of continued success. Amongst the most important of his pictures during this period are—"The Vintage Festival" (1870), "The Picture Gallery" and "The Sculpture Gallery" (1875), "An Audience at Agrippa's" (1876), "The Seasons" (1877), "Sappho" (1881), "The Way to the Temple" (1883), his diploma work, "Hadrian in Britain" (1884), "The Apodyterium" (1886), "The Women of Amphissa" (1877), "The Roses of Heliogabalus" (1888), "An Earthly Paradise" (1891), and "Spring" (1895). Most of his other pictures have been small canvases of exquisite finish, like the "Gold-fish" of 1900. These, as well as all his works, are remarkable for the painting of flowers, textures, and hard reflecting substances, like metals, pottery, and especially marble. He paints with much of the fine execution and brilliant colour of the old Dutch masters. By the human interest with which he imbues all his scenes from ancient life he brings them within the scope of modern feeling, and charms us with gentle sentiment and playful humour. He has also painted some fine portraits, including those of Mr Arthur Balfour, Mr Henschel, Herr Richter the musician, and Dr. Joachim. He was knighted on the occasion of Queen Victoria's eighty-first birthday, 1899. He was made an associate of the Royal Academy in 1876, and a Royal Academician in 1879. He is a knight of the order Pour le Mérite of Germany (Arts and Science Division); of Léopold, Belgium; of the Dutch Lion; of St Michael of Bavaria; of the Golden Lion of Nassau; and of the Crown of Prussia. He is an officer of the Legion of Honour, France. He is a member of the Royal Academies of Munich, Berlin, Madrid, and Vienna. He received a gold medal at Berlin in 1872, and a grand medal at Berlin in 1874; a first-class medal at the Paris International Exhibition of 1878, and medals of honour at the Paris Exhibitions of 1889 and 1900. He is a member of the Royal Society of Water-colours. He received letters of denization from the Crown in 1873.

See also GEORG EBERS. "Lorenz Alma-Tadema," *Westermann's Monatshefte*, November and December 1885, since republished in volume form.—HELEN ZIMMERN. "L. Alma-Tadema, his Life and Work," *Art Annual*, 1886.—C. MONKHOUSE. *British Contemporary Artists.* London, 1899. (C. Mo.)

Almendralejo, a town of Spain, province of Badajoz, 27 miles E.S.E. of Badajoz. Population, 11,766. It has doubled in importance since 1880, owing to the fertility of its neighbourhood, the cereals, fruit, and wine produced in which are easily exported by the Merida-Sevilla railway. There are thirty-six factories for the production of brandy. The town is well built, with broad streets, a good theatre, a bull-ring, and many private mansions.

Almeria, a maritime province in the S. of Spain, with an area of 3300 square miles. The Linares-Almeria railway was completed in 1898, also a line connecting the three provinces of Almeria, Granada, and Jaen, and the three with Madrid. Another line from Baeza to Linares is near completion. The local industries have developed with the growth of the means of communication in the last decade. Manufactures of textiles, chocolate, matches, bricks and chalk, oil and flour mills, foundries, have attained importance. Agricultural interests have received a great impulse in the valleys nearest the sea and on the banks of the Almanzora, Antas, and Aguas. Viticulture has been much developed, chiefly with a view to meet the increasing foreign demand for the fruit; a great number of new plantations have been made to replace the indigenous vines. Esparto grass, oil, cereals, barley, have also been exported in greater proportion than a few years ago. Mining interests have been given a considerable impulse by foreign and native capital. The province contained, in 1898, 210 working mines, covering 4710 acres. Of these 14 were zinc mines, 66 iron, 102 lead, and 21 argentiferous lead. The number of hands employed in 1898 was 6449; a few hundred were engaged in 3 lead and 6 argentiferous lead works. The Sierra Alhamilla railway brought down 50,086 tons of iron ore in 1898. A short railway is being constructed between Calahorsa and Alguip to work 10 million tons of fine ore at Alguip. The live stock consisted, according to the latest official statistics, of 1163 horses, 11,983 mules, 16,221 donkeys, 3299 oxen and cows, 128,078 sheep, 30,513 goats, and 15,041 pigs. 50,350 acres were devoted to the culture of wheat, 105,000 acres to other cereals, 6500 acres to vineyards, 5000 acres to olive plantations, and 44,500 acres to pod fruit. The population in 1897 was 344,681, or only 78 to the square mile. Education is still in a backward condition, though some improvement has taken place in the last twenty years. With a higher rate of births than deaths the population has yet not increased, because of the steady flow of emigration, which carries away to French Algeria annually from 2000 to 3000 Almerians.

Almeria, a port of Spain in the above province. Population, 46,806. It has greatly grown in importance, and in 1898, 1130 vessels, with a total tonnage of 638,551, entered, exactly the same number of vessels and tonnage clearing. In 1897, 178 British vessels of 173,133 tons entered and cleared; in 1898, 191 British vessels (only 13 with British cargoes) of 183,125 tons. Imports in 1898 were chiefly coal, 14,430 tons; patent fuel, 4331 tons; timber, cod, steel, and railway bars. In the export trade 143 British vessels cleared for Great Britain and her colonies with 129,973 tons. Exports were 135,000 tons of iron ore, valued at £56,700; 658,530 barrels of grapes, £237,071; 17,300 tons of esparto, £69,200; and 24,000 cases of almonds, oranges, melons, pomegranates. The western pier, recently built, is 1 mile 77 yards in length, and has a depth of 8 fathoms at the end.

Almodovar del Campo, a town of Spain, in the province of Ciudad Real, 18½ miles S.S.W. of Ciudad Real. There are lace and linen factories. Population in 1897, 12,110. It was formerly an Arab fortress, hence its name, meaning a sphere.

Almora, a town and district of British India, in the Kumaun division of the North-West Provinces, situated on a mountain-ridge 5494 feet above the sea. Population (1881), 7390; (1891), 7826; municipal income (1897-98), Rs.10,135. It has a college, called after Sir Henry Ramsay; a government high school, a Christian girls' school, and 4 printing presses.

The district of ALMORA was recently constituted, together with Naini Tal, by a redistribution of the two former districts of Kumaun and the Tarai. It lies among the mountains of Kumaun, between the upper waters of the Ganges and the Gogra, here called the Kali. Area, 5416 square miles; population (1891), 411,501, the average density being 77 persons per square mile; (1901), 465,876, showing an increase of 13 per cent. The land revenue and rates are Rs.2,65,946; the incidence of assessment being R.0:12:5 per acre; the cultivated area in 1896-97 was 239,684 acres, of which 2602 were under tea; the number of police was 58; there are 122 vernacular schools, with 4080 pupils; the death-rate in 1897 was 24 per thousand. The district includes the military sanatorium of Ranikhet. The nearest railway *viâ* Naini Tal is the extension of the Oudh and Rohilkhand line from near Bareilly to Kathgodam.

Alnwick, a market-town, under an urban district council, and the county town of Northumberland, England, in the Berwick-upon-Tweed parliamentary division of the county, on the Aln, 34 miles N. by W. of Newcastle by rail. By prescription, Alnwick is a borough, and its freemen form a body corporate. This body has no authority over the affairs of the town, but, by the Alnwick Corporation Act, 1882, it is required to expend, out of corporate property, not less than £500 a year in payment of teachers' salaries, &c. in connexion with the corporation schools. The peculiar ceremonies long observed in the initiation of freemen are now discontinued. Area, 4777 acres; population (1881), 6693; (1891), 6746; (1901), 6716. Area of parish, 16,985 acres; population (1881), 7440; (1891), 7428; (1901), 7385.

Alora, a town of Spain, in the province of Malaga, 17 miles W.N.W. of Malaga, on a spur of mountains commanding a fertile plain where maize, sugar-cane, and palms are grown. There are distilleries, Arab ruins of some importance and sulphurous springs, and the town is a favourite summer resort for wealthy families from Malaga. Population (1897), 10,308.

Alost (Flemish *Aelst*), a town of Belgium, on the eastern frontier of the province of East Flanders, on the river Dender, 17 miles S.E. of Ghent by rail. Jute yarns and tissues are manufactured. Population (communal) (1880), 20,679; (1890), 25,544; (1897), 28,771.

Alpena, a city of Michigan, U.S.A., the capital of Alpena county, situated on the eastern side of the lower peninsula, on Thunder Bay, an arm of Lake Huron, at an altitude of 607 feet. Its excellent harbour attracts much lake commerce. It is entered by the Detroit and Mackinaw Railway. Its industries consist mainly in the manufacture of lumber, shingles, and laths. The population in 1880 was 6153, in 1890 it was 11,283, and in 1900 it was 11,802.

Alpes, Basses, a department in the S.E. of France, traversed by the Alps of Provence, and watered by the Var, the Durance, and its affluents, the Buech, the Ubaye, the Bléonne, and the Verdon. Area, 2699 square miles, distributed among 30 cantons and 250 communes. The population fell from 129,494 in 1886 to 112,763 in 1901. The inhabitants readily emigrate to America, more particularly to Mexico. Births in 1899, 2441, of which 63 were illegitimate; deaths, 2537; marriages, 797. The chief towns are Digne (7751 inhabitants in 1896), Barcelonnette, Castellane, Forcalquier, Sisteron, and Manosque. In 1896 there were 604 primary schools, with 18,757 pupils. Nine per cent. of the population was illiterate. The soil of the department is poor in the mountainous region, but more fertile in the valley of the Durance, especially in the neighbourhood of Manosque. The surface under cultivation comprised 841,380 acres in

1896, of which 345,800 acres were in cereals, 172,900 acres in forest, and the rest in grass. The value of the wheat crop in 1899 was £432,810. Rye, barley, oats, as also fodder, give inferior returns, but olive and mulberry are cultivated with success, and the rearing of the silkworm yields good results—2283 cwts. of cocoons in 1899. There are few horses, but the Basses Alpes is among the departments most abounding in mules. In 1899 the live stock numbered 13,570 head of mules and asses, 5920 cattle, 318,350 sheep, 30,270 pigs, and 25,420 goats. The mining industry is not important, counting in 1899 about 3000 tons of coal and 5000 tons of lignite, and the industry in metals comprises only a few workshops. Altogether the department ranks among the least rich in France.

Alpes, Hautes, a department in the S.E. of France, traversed by the Alps of the Dauphiné, attaining in the Oisans Mountains 12,000 to 13,000 ft. high, and watered by the Drac and the Durance. Area, 2178 square miles, distributed among 24 cantons and 187 communes. The population declined from 122,924 in 1886 to 106,857 in 1901. Births (1899), 2519, of which 68 were illegitimate; deaths, 2413; marriages, 703. The chief towns are Gap, Briançon, and Embrun. In 1896 the primary schools numbered 600, with 24,708 pupils. Four per cent. of the population was illiterate. The soil is extremely poor. Out of 795,340 acres under cultivation in 1896, only 212,420 acres were utilized for cereals. In 1898 the wheat crop was of the value of £274,325, by the side of which may be ranked only that of the walnut, the plum, and the mulberry. The production in silk husbandry in 1899 amounted to only 363 cwts. of cocoons. There is no mining or metallurgic industry of any importance.

Alpes Maritimes, a department of the S.E. of France, bordering on Italy. It is traversed by the Alps and watered by the Roya and the Var. The climate is mild on the coast, but cold in the interior. Area, 1444 square miles, distributed among 26 cantons and 153 communes. Population, 238,057 in 1886, 265,155 in 1896, and 320,822 in 1901. There is a strong current of Italian immigration. Births in 1899, 6438, of which 658 were illegitimate; deaths, 6037; marriages, 1848. The chief towns are Nice (93,150 inhabitants in 1896), Grasse, Puget-Théniers, and Cannes. In 1896 there were 480 primary schools, with 24,000 pupils. Seven per cent. of the population were illiterate. The total surface under cultivation was 501,410 acres, of which 156,845 acres were in corn-lands, and 34,580 acres in vineyards. Cereals and fodder yield small returns—wheat (1899) only £212,720; but the production of wine was of the value of £135,000, while the department takes the first rank for the culture of the olive, which amounted in 1899 to 893,000 cwts. Orange and citron, which are also grown, yielded 113,500 cwts. The live stock in 1899 counted altogether 146,050 head, a very low figure, and not compensated by the industrial development. There are some important distilleries.

Alphabet. See WRITING.

Alphonso XII. (1857-1885), king of Spain, the son of Isabella II. and Maria Fernando Francisco de Asis, eldest son of the duke of Cadiz, was born 28th November 1857. When Queen Isabella and her husband were forced to leave Spain by the revolution of 1868 he accompanied them to Paris, and from thence he was sent to the Theresianum at Vienna to continue his studies. On 25th June 1870 he was recalled to Paris, where his mother abdicated in his favour, in the presence of a number of Spanish nobles who had followed the fortunes of the exiled queen. Shortly afterwards he proceeded to Sandhurst to continue his military studies, and while there he issued, on 1st December 1874, in reply to a birthday greeting from his followers, a manifesto proclaiming himself the sole representative of the Spanish monarchy. At the end of the year, when Marshal Serrano left Madrid to take command of the northern army, General Martinez Campos, who had long been working more or less openly for the king, carried off some battalions of the central army to Sagunto, rallied to his own flag the troops sent against him, and entered Valencia in the king's name. Thereupon the president of the Council resigned, and the power was transferred to the king's plenipotentiary and adviser, Canovas del Castillo. In the course of a few days the king arrived at Madrid, passing through Barcelona and Valencia, and was received everywhere with acclamation. In the following year, 1876, a vigorous campaign against the Carlists, in which the young king took part, resulted in the defeat of Don Carlos and his abandonment of the struggle. Early in 1878 Alphonso married his cousin, Princess Maria de las Mercedes, daughter of the duke de Montpensier, but she died within six months of her marriage. Towards the end of the same year a young workman of Tarragona, Oliva Marcousi, fired at the king in Madrid. On 29th November 1879 he married a princess of Austria, Maria Christina, daughter of the Archduke Charles Ferdinand. During the honeymoon a pastrycook named Otero fired at the young sovereigns as they were driving in Madrid. In 1881 the king refused to sanction the law by which the ministers were to remain in office for a fixed term of eighteen months, and upon the consequent resignation of Canovas del Castillo he summoned Sagasta, the Liberal leader, to form a Cabinet. Alphonso died of phthisis, 24th November 1885. Coming to the throne at such an early age, he had served no apprenticeship in the art of ruling, but he possessed great natural tact and a sound judgment ripened by the trials of exile. Benevolent and sympathetic in disposition, he won the affection of his people by fearlessly visiting the districts ravaged by cholera or devastated by earthquake in 1885. His capacity for dealing with men was considerable, and he never allowed himself to become the instrument of any particular party. In his short reign peace was established both at home and abroad, the finances were well regulated, and the various administrative services were placed on a basis that afterwards enabled Spain to pass through the disastrous war with the United States without even the threat of a revolution. (G. F. B.)

Alps.—The writer of the article "Alps" in the ninth edition of this work possessed a more intimate knowledge of that chain than any of his contemporaries. Hence, so far as regards ordinary geography, nothing of importance in it calls for alteration. New surveys have occasionally somewhat altered the heights assigned to mountains, a few of which are noticed below, together with one or two minor corrections or additions; but in one respect, the geology of the Alps and its relation to their structure, very great advances have been made during the last thirty years, and to a brief outline of these this supplementary article will be mainly devoted. Much, no doubt, has yet to be learnt; many questions are still far from being settled; but the labours of numerous investigators, German, Austrian, and Swiss, with some Italian and English, aided especially by the application of the microscope to the examination of rocks, have cleared up not a few difficulties, and laid a safe foundation for future work.

Perhaps the most important advance has been the knowledge gained in regard to the metamorphic rocks, viz., those in which subsequent changes have so affected the original structure that we infer rather than recognize

Meta-morphism.

what it has been. Formerly most geologists supposed that all schists (using the word in its strict sense of foliated crystalline rocks), together with saccharoidal marbles and gneisses, resulted from the alteration of sediments by the combined action of heat, pressure, and water; some even going so far as to maintain that certain igneous rocks represented the extremest stage of this process. In their opinion a mud, if of the right chemical composition, might become in the first stage a schist, in the next a gneiss, in the last a granite. This kind of change, it was believed, had occurred during every geological period, so that, in the one or the other of these, schists and gneisses were identified without hesitation. Hence Mr Ball not infrequently mentions various Palæozoic schists. But, whatever may be the case elsewhere, we may venture to affirm that in the Alps all the rocks thus modified are much more ancient than any to which a date can be assigned. Though in most districts we can only prove them pre-Carboniferous, in the north-eastern region they are pre-Silurian, and in all it is highly probable that they are older than the Palæozoic era, as usually understood. Every effort to strengthen the old hypothesis, and not in the Alps only, has signally failed. For instance, in 1888 two large stems of a fossil plant were asserted to have been found in a gneiss at Guttannen in Canton Berne, thus proving it to be Carboniferous in age; in 1900 this supposed organism was admitted to be a mere *lusus naturæ*. In 1888, also, garnets and staurolites were said to occur in a rock in which belemnites and crinoids could still be recognized, thus establishing the Jurassic age of a great group of schists. In 1890 it was demonstrated that this far-reaching hypothesis had no better foundation than an erroneous identification of the two minerals, those actually present having no real bearing on the question.

Effects of pressure on Alpine rocks.

Of the advances, mentioned above, none is more important than the recognition of the effects due to severe pressure. That it had produced cleavage in ordinary sediments was long since generally admitted; that in some cases it had generated minute scales of mica in vast numbers and converted a slate into a "microscopic" schist was more than conjectured; but it is now ascertained that crushing due to the great earth movements which have formed mountain chains has produced cleavages even in crystalline igneous rocks, and led to the development of various minerals, especially in connexion with the new surfaces, so that many gneisses and some mica schists are only granite modified by subsequent pressure. Other gneisses, however, and certain cognate schists, especially those with a conspicuous mineral banding, are the result of fluxional movements in the magma at the time of consolidation; while a third group of schists, and possibly some gneisses, may be explained by the old hypothesis. One difficulty doubtless still exists: in certain instances it is almost impossible to determine whether a very fine grained schist represents a stage in the last-named process or results from the pulverization of a crystalline rock. This uncertainty, however, does not vitiate the general statement that a group of true schists can be distinguished from one composed of sediments in which changes only of microscopic magnitude have occurred, neither does it prove that the two may be present in the same geological formation; it only shows that in certain cases nature has so damaged her own inscription that it is no longer legible.

Age of the Alpine rocks.

Thus, the following facts in regard to the nature and age of the Alpine rocks would now be generally admitted by those who have studied them in the field as well as under the microscope. Those rocks (mainly sedimentary) which can be assigned to a definite geological age rest upon a fundamental crystalline mass of much greater antiquity. This appears to be separable into two groups, generally, though not always, rather sharply distinguished. The lower one consists mainly of granitoid rocks and gneisses, the majority, if not the whole, being igneous rocks modified by subsequent pressure. Some are later in date than others; for instance, the protogine of the Mont Blanc range, long supposed to be the oldest rock, is clearly intrusive in the adjacent gneisses. The upper group is mainly composed of mica schists, commonly calcareous, passing on the one hand into marbles, on the other to quartz schists; being thus metamorphosed sediments. With these are associated, sometimes abundantly, hornblendic and chloritic schists, in great part at least modified igneous rocks. Rocks of similar character occur also, though less frequently, in the other group; and normal granites, gabbros, and serpentines in both, the age of which has not yet been certainly determined.

These rocks, the foundation-stones of the Alps, are followed, but so far as is known only in the north-eastern region, by sedimentary deposits of Silurian and Devonian age. Representatives of the Carboniferous system are more widely distributed, though generally in isolated strips, folded in among the crystalline masses. These are commonly dark in colour, and vary from good slates to coarse conglomerates or breccias, which often are full of pieces of the older schists and gneisses. They occasionally contain plant remains or a little anthracite, but marine fossils occur in the Gailthal and elsewhere in the Eastern Alps. The Permian system also is generally represented sporadically, as a rule by grits and conglomerates, indicating that high ground existed in the neighbourhood; but during this period the region of the South-eastern Alps was the scene of volcanic activity, which produced the great masses of "porphyry" around Botzen and Predazzo, which can be traced westwards beyond the lower end of Lago Maggiore. Outbreaks of this age can be detected in other localities, as on the Windgelle and to the east of Vernayaz, on the right bank of the Rhone. In South-eastern Tyrol the volcanic discharges continued into the Triassic period, and were renewed, in the opinion of some geologists, at a much later date. In this district the Trias is represented by sedimentary strata, consisting largely of pure dolomitic limestones, some of which have been thought to be coral reefs. Be this as it may, the existing mountains can hardly represent ancient atolls, as some have supposed. At this period, also, the surface contours of the Alpine region must have been very irregular, for in other parts, notably in the Pennine, Central, and Dauphiné Alps, the Trias is either absent or is represented by friable limestones and even gypsum, often not more than a few feet in thickness.

In regard to the rest of the Mesozoic and the Kainozoic systems, little need be added to the account given in the ninth edition of this work, except in regard to a perplexing deposit called the Flysch. It is a thick mass of mudstones, more or less gritty and generally unfossiliferous, which, it is now ascertained, represents identity of physical conditions rather than exact contemporaneity of deposit. In the northern part of the Eastern Alps it begins before the close of the Cretaceous period; in the southern its greatest extent is from the top of the Middle Eocene to that of the Middle Oligocene. In the Western Alps it ranges, in the Swiss portion, from the bottom of the Middle Eocene to the top of the Lower Oligocene, while in the south it does not begin till the Upper Eocene. It contains locally beds of breccia and even large isolated boulders, the volume of which is sometimes, as in the Habkernthal, several cubic yards, representing granites not known to occur elsewhere in the Alps; in other places, for example near Sepey, the erratics may not have come from any great distance. But it is difficult to account for their presence. Ice is the most obvious means of transport; but the temperature during Eocene and Oligocene ages appears to have been much higher than it now is, being at a maximum in the former, while no evidence can be found of the existence of mountains on or near the present site of the Alps. Some authorities place the requisite range immediately to the north, supposing its roots to be buried beneath the Miocene deposits of the Swiss lowlands, but it would be strange if such an important mass had so quickly vanished and left "not a rock behind."

Geological structure.

A geological map of the whole Alps, on a scale large enough to indicate clearly the above-mentioned divisions, shows them to be arranged in zones which are rudely symmetrical with the outline of the chain, the crystalline rocks occupying its central portion. But on examination irregularities appear which are far from unimportant. The southern sedimentary zone, for instance, gradually becomes attenuated as it is followed from its eastern end westwards, till it disappears rather beyond Lago Maggiore, after which crystalline rocks rise directly from the Piedmontese plain. The structure of the chain, also, is the most simple in its eastern part, a central range of crystalline rock forming the watershed, with two masses of sedimentary rocks flanking it north and south, through which the rivers have cut their paths. But this structure, as we approach the headwaters of the Inn, becomes more complex, as we shall explain in speaking of the hydrography, the change being probably connected with a feature in the geology. The outcrops of the rocks, as we have said, conform to the general course of the chain at its eastern end, trending almost west, but then they gradually sweep round the north Italian plain till at last they are almost parallel to their original direction. This structure, however, is modified by another of minor, but sometimes considerable importance, which is most conspicuously exhibited in the district about Lago di Garda. Here a broad belt of Mesozoic sedimentary rock, bounded on the south by a line extending approximately from Brescia to Verona, runs across the chain in a N.N.E. direction; flanked on the west by crystallines, and on the east, though less continuously, by the same and by great masses of Permian "porphyry." This belt may be traced by outlying patches across the central range until near Innsbruck it apparently dies out against the northern sedimentary range. It is in this neighbourhood, and the coincidence is significant, that the Alps attain their greatest width from north to south. Here, in fact, the dominant wave-like folds, of which the Alpine chain is composed, are traversed obliquely by a syncline. To the west of this, passing approximately between Chur and Mals, we find traces of a second syncline with the same general trend, but possibly subdivided by a central rise, while the structure of the crystalline rocks between the two main synclines hints at the existence of a corresponding anticline. A similar structure is suggested in the Bernina group, and yet farther to the west (in maps on a larger scale); while from Mont Blanc for a considerable distance to the south the whole chain has a general trend, in the same direction, and that is repeated by the outlying crystalline masses, the outcrops of which, as far as Dauphiné, run conspicuously from N.N.E. to S.S.W. How this structure is connected with the making of the Alps will be presently considered. But since ridge and furrow, swelling and dimple, are closely related on the earth's surface, any complete discussion of the physical history of the Alpine chain must regard it as inseparable from the Apennines on the one side and the mountains of Istria and Dalmatia on the other, and as related in some way or other to the basin of the Adriatic and the plain of Northern Italy. But putting aside this more general question and restricting ourselves to the Alps proper, we must bear in mind two facts in any attempt to explain their complications:—(1) This chain was not the product of a single set of movements, but of two at least, which were separated by a considerable interval: the one occurring when the Eocene was passing into the Oligocene, the other in like way between the Miocene and Pliocene. (2) That the sedimentary masses thus affected were deposited on an irregular floor of more ancient, chiefly crystalline, rocks; parts at least of the present site of the Alps having been mountainous districts in Carboniferous and again in Permo-Triassic times. These irregularities in the thickness and strength of materials would cause corresponding inequalities in their resistance to pressure, and thus introduce numerous complications. Still, though allowance must be made for them, the general process in the rise of the Alps can be inferred from the experiments of A. Favre, H. M. Cadell, and Bayly Willis, and be described as follows:—Lateral pressures have formed a group of great folds in the earth's crust; these sometimes have been gradually bent over until their axial planes became inclined to the horizon. The strain occasionally has continued till the masses have been ruptured along these planes, and the upper portion of the fold has then slid on above the lower, thus producing an "overthrust fault." During these processes the less pliant crystalline masses are crushed and sheared, thus giving rise to structures analogous to cleavage, and often suggestive of bedding. The remarkable folding in the Alpine rocks has long been known, but the recognition of these other structures is comparatively recent, and its absence seriously detracts from the value of not a few geological maps and memoirs. One instance may suffice as an example:—The North Swiss Alps between the valleys of the Reuss and the Rhine, especially near the Glarnisch, exhibit a singularly complicated structure, the strata apparently being bent over to form a double fold, with complete inversion on both sides. No doubt the arrangement of the strata suggests this structure; but the mechanics of the process are so difficult to understand that Rothpletz with several other authorities explains it as a combination of overfolding followed by great overthrust faulting, and this seems to the present writer far more probable.

Another perplexing structure may be mentioned here which is found in certain mountains on the northern face of the Alps, such as the Mythen and Stanzerhorn, and has of late attracted much attention. These, called Klippen, are abrupt pyramidal masses, the beds in the upper part being not only older than those in the lower, but also "contorted, fractured, crushed, and mixed up," while the newer are comparatively undisturbed. They are due to overfolding and overthrusting, being remnants of larger masses, the greater part of which has been removed by denudation; but that they have been forced into their present position from so great a distance as the Briançonnais, as some have suggested, is hardly possible.

Hydrography.

It is now generally admitted that the valleys in mountain regions are mainly the results of denudation, though the movements and structures of the uprising land masses must have done much, especially at first, to determine the directions in which the water ran. Thus the Alpine valleys may be divided broadly into valleys of dip and valleys of strike—the former, as the name implies, following the dip of the strata, and so being the narrower and steeper; the latter running along their outcrop, and thus the broader and more level. These are generally excavated in a mass softer than those adjacent on either side, whether it is intercalated or infolded. When this mass is prolonged for a great distance the strike valleys are sometimes divided by low watersheds into different drainage systems. Of this, the Upper Rhone, the Reuss at its outset, and the Vorder Rhein afford an excellent example. They are excavated in an infold, composed mainly of Jurassic rocks, which is divided by watersheds at the Furka and Oberalp passes. As valleys of strike are both supplied and drained by valleys of dip, the course of an Alpine river, unless affected by some of the irregularities mentioned above, has a rude resemblance to the outline of a flight of steps.

River courses.

In the Eastern Alps, and in the southern more than in the northern region, the main lines of drainage run towards the east. The precise cause is not easily determined, but probably it is connected with the rather abrupt cessation of the chain at this extremity. The watershed then follows the central or crystalline range until on approaching the upper part of the Inn valley it bends towards the south, returning from the Maloja Pass, in the neighbourhood of the Rheinwaldhorn, nearly to its former position. Thus the upper waters of the Inn and the Hinter Rhein are supplied from a district distinctly south of the usual line of the watershed. The precise cause of this flexure is also difficult to determine, but it is probably connected with the syncline, mentioned in a former paragraph. The watershed afterwards follows the crest of the Lepontine and Pennine Alps, having to the north a second range—largely consisting of crystalline rocks—the Bernese Oberland—higher than the former and not much inferior to the latter, through gashes in which the Reuss and the Rhone discharge their waters. From this we infer that the structure of this region, when the river system of the Alps was first determined, was a simpler one, more like that of the Eastern Alps; the Pennine Alps, forming a watershed, flanked on either side by sedimentary ranges, of which the southern has been removed by denudation, and the northern greatly exaggerated by a later series of movements, which, however, must have been slow enough to allow the rivers to deepen their valleys *pari passu* with the rise. Though the range of Mont Blanc is connected with that of the Oberland, its crest forms the watershed, for this passes from the Great St Bernard over the low gap of the Col Ferret, and by the Little St Bernard returns to its former course at the Rutor; a diversion probably due to the exceptional elevation of the northern range in the vicinity of Mont Blanc, which has enabled it to discharge part of its water into the Val d'Aosta. Its original inferiority is, however, suggested by the fact that one tributary of the Durance actually drains the north-eastern flank of the now-dominant *massif*. South of the Little St Bernard Pass the watershed keeps in its old position along the crest of the crystalline mass which encloses the Italian plain, while the prolongation of the Mont Blanc *massif* may be traced through the Tarentaise and Maurienne as far as the High Alps of Dauphiné. The structure of these masses, however, is anything but simple. The Romanche, rising on the Col de Lautaret, forces its way through two crystalline ranges, that of the Grandes Rousses and of the Belledonne, between which is an infold of Jurassic rocks. Do these two crystalline masses, together with the other and larger one, represent the double range system (Mont Blanc and the Brevent) farther north; or should the chief Dauphiné mass (that around the Pointe des Écrins) be connected, as some think, with the crystalline ridge, of which the Grande Casse and Mont Pourri form parts; or is this latter ridge merely an outlier of the great central system, which farther north is represented by the Pennines? The fact that the zone of the Briançonnais (an important trough of sedimentary rocks) in the main keeps to the west of the Grande Casse-Pourri *massif* seems to link the latter to the central system.

Movement of the larger watersheds.

It is generally admitted that, whatever be the case in regard to Mont Blanc, the headwaters of streams flowing towards Italy have frequently trespassed on those running in the opposite direction. The most striking instance is afforded by the Maloja Pass. Here the head of the Inn valley is an almost level trough, about 9 miles long, between lofty mountains, which is terminated at the actual pass by precipices descending to the Val Bregaglia. But it is inferred from studying the surrounding district that the watershed once lay some 6 miles farther south, the Val Forno and Val Albigna being then tributaries of the Inn, but that it has been completely cut away by the greater erosive action of the Maira, which has annexed the drainage of these two glens. Those shorter trenches, which afford a passage to the great Alpine roads, may be similarly explained, and such apparent anomalies as the structure of the mountains near Zermatt. Here the truncation of the range between the two arms of the Visp at the Strahlhorn, the wide gap between it and Monte Rosa, and the apparent disappearance of the Gornergrat-Stockhorn spur, may be due to the recession of the head of the Val Anzasca.

Relation of the movements.

The Alpine chain, as it exists, is the result of two separate sets of movements during the Tertiary era in a region which, as stated above, had already been the scene of disturbances. But the history of the former set is not yet certain. Some authorities think that the apparent change in general structure, near the headwaters of the Inn, indicates that the Alps to the east and the west were produced by independent disturbances. But even if the other view be adopted, the movements may not have been uniform or quite simultaneous. The effects of the second set were, at any rate, more marked in the Central and Western Alps, as is shown by the facts already mentioned, and by the upheaval of the nagelflue (gravel from the rivers of the Oligocene Alps), to full 6000 feet above sea-level in the Rigi and the Speer. Some recent writers have maintained that parts of the Alps have been affected by torsional movements. It is, however, difficult to understand the mechanical conditions under which such movements, in the strict sense of the term, could be produced in the earth's crust, though no doubt unequal resistances to pressure and the joint effects of successive sets of thrusts, acting in different directions, would present a very similar aspect. Apart, however, from this it has been demonstrated, especially since 1870, that the structure of the Alps is far more complicated than was formerly supposed. It was also believed that in the Alps igneous rocks of Tertiary age occurred only in the Vicentin and in one or two isolated spots; recently, however, it has been maintained (though the question is still *sub judice*) that some of the intrusions in the Dolomite district belong to this era instead of to the Trias.

Glaciers.

Much attention has been given to the movements and physics of glaciers. In the Alps their average motion is not far from a foot a day; while the study of other regions has shown that, *cæteris paribus*, the larger the glacier the quicker its pace. Special attention has been paid to the changes in volume exhibited by the Alpine glaciers. These are sometimes irregular, but as a rule they affect the majority of glaciers almost simultaneously. A universal shrinkage set in soon after 1860, but now the tide seems to have turned. The diminution in some cases has been very great; for instance, the thickness of the Unter Grindelwald glacier has been reduced by 115 feet. Its periods of advance during the last two centuries were 1703-20, 1770-1779, 1814-1822, 1840-1855. It is now generally agreed that during the Glacial epoch the Alpine ice more than once advanced and retreated. For instance, the glacier of the Rhone not only welled up against the flank of the Jura, where it dropped the noted *Pierre-à-bot* and other erratics, but also descended to within a few leagues of Lyons, thus attaining a total length of about 270 miles. As an example of fluctuation we may take the ancient Limmat glacier, which many authorities believe to have exhibited the following phases:—(1) First advance indicated by morainic deposit on the Uetliberg; (2) Retreat and formation of the Deckenschotter (coarse conglomerate); (3) Second advance (extension to Jura) represented by moraines considerably above the level of the Lake of Zurich; (4) Retreat and deposit of the gravels forming the valley plain of the Limmat; (5) Third advance, limited by the moraine near Killwangen. That most of the Swiss lowland was for a time covered by ice (forming a huge "piedmont" glacier) is now generally admitted. This would require the mean temperature to be much lower than at present, probably about 18° F. at the time of maximum extension, while the glaciers would practically disappear from the Alps with a rise of 9° F.

The hypothesis attributing the greater lake basins in the Alps to the erosive action of glaciers has been declining in favour during the last thirty years, as the subject has been more thoroughly and precisely studied. Many, perhaps the majority of geologists now admit that the action of glaciers is *abrasive* rather than *erosive*, and that they can excavate only in special circumstances and to a limited extent. Some tarns or lakelets may have been thus formed; in others the water is dammed back by old moraines or berg-falls; in others (though *not* Lago di Tremorgio) a hollow has been formed by the removal of soluble rock; but the larger Alpine lakes are now more generally attributed (like those of the St Lawrence region) to differential movements in the beds of pre-existing valleys.

Addenda and corrigenda.

A few corrections and additions to the article in the ninth edition of this work may be noted here. In regard to the Alpine mammals it is now certain that the ibex or bouquetin is restricted to the Eastern Graians. The brown bear still occurs in one or two of the more remote districts, with the lynx and wild cat. The stoat (*P. erminea*) ranges up to 10,000 feet. The golden eagle, though rare, and the raven may be added to the birds; one or two of the small *raptores* are not uncommon; the black redstart, the siskin, the crested titmouse, the crossbill, and the nutcracker are not rare; the wall-creeper (*Tichodroma muraria*), the Alpine accentor, the Alpine pipit, and the snowfinch occur in the upper region. "Grouse" in the list of game birds presumably means the hazel grouse, for of course *Tetrao scoticus* does not occur; the ptarmigan is rather common well above the tree-line, and ranges to a great height. The blackhead and common gull frequent the lakes, with the black and common terns. In the mountain lakes *Salmo lacustris* has been found at 8626 feet, and *Triton alpestris* slightly above that elevation. On page 821, col. 1 (*Ency. Brit.* ninth edition, vol. i.), the Piz Tremoggia (11,322 feet) and Piz Cambrena (11,834 feet) hardly deserve to be called dominant peaks of the Bernina group. The height of the Gross Venediger is 12,008 feet.

Even since 1875 the Alps have been made much more accessible. Railways have been carried over the Brenner, Arlberg, and Brunig passes, and through the Mont Cenis and the St Gothard by the aid of long tunnels. The piercing of the Simplon is now in progress. Several light railways on more than one plan have been constructed, as that from Chur to Thusis, or from Visp to Zermatt, those up the Rigi, Pilatus, over the Wengern Alp, even up the Gornergrat; the latest attempt being to burrow up to the summit of the Jungfrau. Carriage roads have replaced mule paths, as at the Lukmanier, Fluela, Oberalp, and Col de Forclaz passes, also to Chamouni from Vernayaz by Salvan, and in several other places. Club-huts have been erected in many convenient positions among the peaks and glaciers; hotels have multiplied, not only in the villages but also on commanding situations. One has even been built on the Gornergrat, thus ruining the grandest readily accessible point of view in the Alps. The result has been to flood many parts of the Alps with tourists, to whom their beauties make no real appeal, and thus to take away much of their charm.

In several instances new surveys have slightly altered the altitudes of peaks or passes given in Mr Ball's list; but it has been thought sufficient to substitute exact figures for those which he was obliged to leave as approximations, except in two or three cases where the writer has failed to obtain more precise information.

		Feet.
Passes of the Maritime Alps	Col de Santron	8823
	Col de Lauzanier	8714
Peaks of the Cottian Alps	Pointe de St Anna; the higher summit is called P. de la Fonte Sancta, and is	11,057
Passes of the Cottian Alps	Col d'Izouard	7835
Peaks of the Dauphiné Alps	Pic d'Ailefroide	12,878
Peaks of the Graian Alps	Grande Motte	12,018
	Bec de l'Invergnan	11,838
Passes of the Graian Alps	Col de Lauzon	10,831
Peaks of the Pennine Alps	Pointe de Salles	8183
Passes of the Pennine Alps	Col de Vessona	9167
Passes in the Bernese Alps	Monch Joch	11,385
	Triftlimmi	10,170
	Geschenenlimmi (?Sustenlimmi)	10,180
Passes in the North Swiss Alps	Sardona Pass	9317
	Kamor Pass	?5900
Passes of the Rhætian Alps	Passo di Val Viola	8070
	Gavia Pass	8465
	Bieler Joch	6630
Peaks of the Lombard Alps	Pizzo dei Tre Signori	11,020
	Brenta Alta	9735
Passes of the Lombard Alps	Gampen Pass	5060
	Croce Domini Pass	6215
	Passo di S. Valentino	9080
Passes in the Vindelician Alps	Madelejoch	6665
	Kaiserjoch	7560
Passes in the Central Tyrol Alps	Gebatsch Joch	10,640
Passes in the Styrian Alps	Rottenmanner Tauern	4150
	Fladnitz Pass	?5930
	Gleinalp Pass	5210
Peaks of the South Tyrol and Venetian Alps	Marmolata	11,020
	Drei Zinnen (highest)	9850
	Cimon della Pala	10,450
	Palle di S. Martino	9830
	(Perhaps Cima di Vezzana 10,465 intended)	
	Marmarolo	9620
Passes in the South Tyrol and Venetian Alps	Peuschelstein Pass	5000
Peaks of the South-eastern Alps	Kellerwand	9104
	Jof di Montasio	9030
Passes of the South-eastern Alps	Piano di Sappada	4275
	Skarbinja Joch	6240

For topographical information, see the publications of the English, French, Italian, Swiss, German, and Austrian Alpine clubs; the well-known guide books of Murray, Baedeker, and Joanne, the Climbers' Guides, the *Guide du Haut Dauphiné;* Ball's *Alpine Guide* (new edition, vol. i. "Western Alps," edited by W. A. B. Coolidge, 1898, alone published); and *Notes for Travellers in the Alps* (1899), by the same editor (being the "General Introduction" to Ball's *Guide*, revised and rewritten). This last contains a list of all the more important books and maps on the Alps, with articles on their geology and physical geography, natural history, social life, &c. Among the more important books published of late years may be mentioned the following:—BAILLIE-GROHMAN, W. A. *Sport in the Alps*, 1896.—CONWAY, Sir MARTIN. *The Alps from end to end*, 1895.—DENT, CLINTON T. *Mountaineering* (Badminton Library), 1892.—FORBES, J. D. *Travels through the Alps* (revised and annotated by W. A. B. Coolidge, 1900).—FRESHFIELD, D. W. *The Italian Alps*, 1875.—GÜSSFELD, PAUL. *In den Hochalpen*, 1886.—LENDENFELD, R. von. *Aus den Alpen*, 2 vols., 1896.—LUBBOCK, Sir JOHN. *The Scenery of Switzerland*, 1896.—MAIN (BURNABY), Mrs. *The High Alps in Winter*, 1883.—MATHEWS, C. E. *The Annals of Mont Blanc*, 1898.—ROMAN, J. *Dictionnaire Topographique du Départment des Hautes Alpes*, 1888.—SINIGAGLIA, L. *Climbing Reminiscences of the Dolomites* (trans.), 1896.—SOWERBY, J. *The Forest Cantons of Switzerland*, 1892.—UMLAUFT, F. *Die Alpen*, 1887 (*The Alps*, 1889).—WHYMPER, E. *Chamonix and the Range of Mont Blanc*, 1897; *The Valley of Zermatt and the Matterhorn*, 1897.

The list of papers and books on Alpine geology and physical geography is also very extensive. Of the former the more important have appeared in some of the following publications:—*Académie des Sciences de l'Institut de France* (Comptes Rendus); *Accademia Reale dei Lincei* (Atti); *Annales des Mines*, *Deutsche geologische Gesellschaft* (Zeitschrift); *Geological Society of London* (Quarterly Journal); *Kaiserliche Akademie der Wissenschaften* (Vienna) (Sitzungsberichte); *Königliche Bayerische Akademie der Wissenschaften* (Sitzungsberichte); *Società Geologica Italiana* (Bollettino); *Société Géologique de France* (Bulletin); *Neue Denkschriften der allgemeinen Schweizerischen Gesellschaft.* The last-named contains (vol. xxxvii.) an important paper by Dr ZSCHOKKE, on the "Fauna of the higher Mountain Lakes," and one by Dr BALTZER (vol. xxxiii.) on the "History of the Unter-Grindelwald Glacier."—The following more special books may be added:—BARETTI, M. *Geologia della Provincia di Torino: Atlas*, 1895.—DIENER, C. *Der Gebirgsbau der Westalpen*, 1891.—FRAAS, E. *Scenerie der Alpen*, 1892.—FRECH, F. *Die Karnischen Alpen*, 1892.—HEIM, A. *Untersuchungen über den Mechanismus der Gebirgsbildung* (2 vols. and atlas), 1878; *Handbuch der Gletscherkunde*, 1885.—MOJSISOVICS, E. von. *Die Dolomitriffe von Südtirol und Venetiens*, 1879.—SUESS, E. *Die Entstehung der Alpen*, 1875. See also *Das Antlitz der Erde. Livret-Guide Géologique dans le Jura et les Alps de la Suisse*, 1894.—FAVRE and SCHARDT. *Eclogæ Geologicæ Helveticæ* now contains summaries of papers on Alpine geology.

The following works are official:—*Austria: K. K. Geologische Reichsanstalt* (Abhandlungen and Jahrbuch). *France: Bulletin des Services de la Carte Géologique de la France. Italy: Reale Comitato Geologico d' Italia* (Bolletino). *Switzerland: Beiträge zur geologischen Karte der Schweiz.*

The Alps, at least up to the frontier, are included in the Government maps of the following countries:—*Austria:* "Special Karte des österreichisch-ungarischen Monarchie" scale $\frac{1}{75,000}$, 763 sheets, 1874-1888; a revised edition now appearing.—*France:* "Carte de l'État Major" (type 1889), scale $\frac{1}{80,000}$, 258 sheets.—*Italy:* "Carta Topographica del Regno d' Italia," scale $\frac{1}{100,000}$, 277 sheets, 1884-97.—*Switzerland:* "Topographischer Atlas der Schweiz" (Siegfried atlas), scale $\frac{1}{50,000}$ for mountains, 589 sheets, 1870.—Others, with maps of special districts, are enumerated in *Hints and Notes for Travellers in the Alps*, cli., and a list of geological maps is given (p. xcviii.). The best and most recent geological map of the whole chain is F. NOË, *Geologische Uebersichtskarte der Alpen* $\frac{1}{1,000,000}$, 1890. (T. G. B.)

Alsace-Lorraine, in German *Elsass-Lothringen*, a German Imperial territory formed out of the former French provinces of Alsace and Lorraine, lying between the Rhine on the E., the Bavarian Palatinate, Prussian Rhine province, and grand-duchy of Luxemburg on the N., France on the W., and Switzerland on the S. Maximum length, N. to S., 118 miles; maximum breadth (in the N.), 106 miles; maximum breadth (in the S.), 22 miles. The determining features of its physical conformation are the Vosges Mountains and the Rhine. The foothills of the former and the valley of the latter account for almost the entire area of Alsace; and the greater part of Lorraine belongs to the high-plain which stretches from the Moselle to the Saar, but seldom rises to 1300 feet above the sea-level. The drainage of the Vosges valleys and of the Rhine valley is collected and carried into the Rhine about 10 miles below Strasburg by the Ill. The climate is on the whole temperate—warmest in the lowest districts (460 ft. above sea-level) of N. Alsace, and coldest on the summits of the Vosges, where snow lies six months in the year. The mean annual temperature at Strasburg is 49·8° Fahr., at Metz 48·2°; the rainfall at Strasburg 26¼ inches, and at Metz 27¼ inches. The Rhine valley is in great part fertile, yielding good crops of potatoes, cereals (including maize), sugar beet, hops, tobacco, flax, hemp, and products of oleaginous plants. But wine and fruit are amongst the most valuable of the crops. The cereals chiefly grown are wheat, oats, barley, and rye. Great quantities of hay are harvested. In 1898 about 3000 acres were planted with tobacco, and the yield, when dried, weighed about 3000 tons; and 73,730 acres were planted with vines, the yield being 11,348,000 gallons of wine, valued at £950,000. These statistics embrace also the production of Lorraine, where agriculture is less strenuously carried on, and the fertility of the soil is less. But Lorraine possesses, in compensation, greater riches *in* the earth, in her coal and iron and salt mines, the output of which in 1897 was 1,057,550 tons of coal, valued at £441,970; 5,360,840 tons of iron ore, valued at £615,880; and 70,578 tons of salt, valued at £39,860. The total mineral output of Alsace-Lorraine in 1898 was valued at £1,276,340. In 1897 the live stock of the territory numbered 138,689 horses, 512,329 head of cattle, 375,635 pigs, and 93,204 sheep. Cows are grazed on the S. Vosges in summer, and large quantities of cheese (Münster cheese) are made and exported. Total population (1901), 1,717,451.

The farms in Alsace are mostly small, and are held partly as a private possession, partly on the communal system; in Lorraine there are some larger occupations. The distribution and classification of the holdings was as follows in 1895:—

Under 2½ acres.	2½ to 25 acres.	25 to 250 acres.	Above 250 acres.	Total farms.
98,668	119,955	12,919	407	231,947

The total area of these 232,000 farms was 2,230,368 acres, the rest of the territory being covered by forests, barren lands, lakes, roads, &c. Agriculture and wine-growing are general industries; but coal and iron mining are special to Lorraine, as the manufacture of cottons, and on a smaller scale of woollens, is special to Alsace, the chief centres of the industry being Mülhausen, Colmar, and the valleys of the Vosges. The territory has always been the centre of an active commerce, owing to its situation on the confines of Germany, France, and Switzerland, and alongside the great highway of the Rhine. The communications embrace some 1090 miles of railway (1898: of which about 1000 miles belonged to the state), a good system of roads, and several canals, in addition to the rivers. Administratively the territory is divided into the following three districts:—

Districts.	Area in sq. miles.	Population.			Density per sq. mile, 1895.
		1875.	1885.	1895.	
Upper Alsace .	1354	458,374	462,549	477,477	352·6
Lower Alsace .	1845	593,180	612,077	638,624	346·1
Lorraine . . .	2402	480,250	489,729	524,885	218·5
Total . . .	5601	1,531,804	1,564,355	1,640,986	292·9

On the sex division, 833,173 were in 1895 males, and 807,813 females. The percentage of illegitimacy in the same year was 8·3, also in 1895. The rural population embraced 54·8 per cent. of the whole, the urban population 45·2 per cent. The largest towns are Strasburg (the capital of the territory), Mülhausen, Metz, Colmar, Hagenau, Saargemünd, Gebweiler, and Markirch, all above 10,000 inhabitants each. Classified according to religion there were, in 1895, 358,458 Protestants, 1,248,791 Roman Catholics, and 32,859 Jews. Education is provided for (1898) at the university of Strasburg, in 23 classical and pro-classical schools, in 13 modern schools, and in nearly 3500 schools of a more elementary character. Over 80 per cent. of the people speak German as their mother-tongue, the rest French, or a patois of French. The supreme executive officer of the territory is a governor-general, who is appointed by the German emperor; but he is assisted by a ministry of four members, under the chairmanship of a secretary of state, and by a council of state numbering 58 members, and consisting of the governor-general, secretary of state, chief provincial officials, and 8 to 12 nominees of the emperor. In 1900 the revenue was estimated at £3,020,242, and the expenditure at £3,002,733. There was also an extraordinary budget of £199,822 revenue and £217,382 expenditure. Customs and indirect taxes yield more than three-fifths of the total revenue, and direct taxes less than one-fourth. The state forests give about one-ninth of the whole. The public debt, capitalized, amounted in 1900 to £1,192,150, and the territory's contribution to the imperial exchequer to £830,425 in 1900. The higher administration of justice is devolved upon six provincial courts and a supreme court, sitting at Colmar. Moreover, there are purely industrial tribunals at Mülhausen, Thann, Markirch, Strasburg, and Metz. The fish-breeding establishment at Hüningen in Upper Alsace should be mentioned. (J. T. BE.)

Alston, or ALDSTONE, a market-town and railway station in the Penrith parliamentary division of Cumberland, England, 29 miles by road E.S.E. of Carlisle. The preparation of umber for colours and paint is carried on. There are limestone quarries, and argentiferous lead, copper, and blende are found in the neighbourhood. Coal is worked chiefly for lime-burning. Area of parish (under a rural district council), 36,968 acres; population (1881), 4621; (1891), 3384; (1901), 3133.

Altai, the name given to an extensive region of Southern West Siberia, composed of many mountain ranges and broad, fertile valleys, similar in character to, but covering an area nearly three times larger than, Switzerland (52,500 square miles). It is watered by the upper tributaries of the Ob—Biya, Katuñ, Charysh, and partly Tom, as also the Upper Irtysh. It has a quadrangular shape, and is bounded on the S.W. by the Black (Chornyi) Irtysh, on the S.E. by the high plateau of north-western Mongolia, on the N.E. by the government of Yeniseisk, parts of which belong to or merge into the Altai, and on the N.W. by the lowlands of Tomsk, strewn with many lakes and watered by the Ob. The name of Altai—Ektagh Altai, or Southern Altai, or Chinese Altai, and Altain-nauru—is also given to a mountain range which separates the drainage area of Lake Kobdo from that of the Black Irtysh and its former tributary, the Ulungur. This range borders on the N.—as the Eastern Tian-Shan borders on the S.—the great and broad Dzungarian trench, excavated in a north-west to south-east direction in the High Plateau of East Asia, and leads with a gentle gradient from the lowlands of Lake Balkhash to the high level of the plateau.

The highest parts of the Altai region are along the border of the Mongolian plateau, where in all probability we have a border-ridge similar to the Western Sayan, which might be named the Sailughem range. Its south-eastern slope is short and gentle for the most part, as it leads to the 4000-5000 feet high plateau, upon which rise the tributaries of the Kemchik (Yenisei) at a great altitude, and the lakes Ubsa-nor and Kobdo are situated. Several small plateaus, such as the Ukök (7800 feet), Chuya (6000 feet), Kendykty (8200 feet), and Juvlukul (7900 feet) plateaus, situated along a common axis running south-west to north-east, enter into the composition of that mountain range. There is no tree vegetation on these heights; only the dwarf birch (*B. nana*) stands the cold, and the *Arctomys bobac* makes his furrows in the frozen mud. Easy passages lead from these alpine lands to the high plateau of Mongolia, but the slopes directed towards the Altai rivers are extremely steep and very difficult of access. The snow-line lies here at an altitude of about 9000 feet, and many summits rise above that level, especially the Byelukha (the Mont Blanc of the Altai), whose two summits reach 14,800 and 14,500 feet respectively, and give origin to six large and several small glaciers (30 square miles aggregate area). The Kuitun, 12,000 feet, and several other high peaks belong to the same range. Several chains of mountains fill up the space between the Sailughem and the lowlands of Tomsk, but their mutual relations are yet far from being well known, and they are mostly described under local names. Such are the Chuya Alps (Chuiskiye Byelki), having an average altitude of 9000 feet, with summits rising from 11,400 to 12,000 feet, and giving origin to at least ten glaciers on their northern slope; the Katuñ Alps (Katunskiye Stolby); the Kholzun range; the range which is known locally under the names of Korgon (Korgonskiye Byelki, 6300 to 7600 feet), Talitsk, and Selitsk ranges; the Tigeretsk Alps, and so on. Several secondary plateaus of lower altitude are also distinguished by geographers.

The picturesque and fertile valleys of the Altai, surrounded as they are by majestic alps, are, of course, better known. The Katuñ valley begins as a wild gorge on the south-west slope of the Byelukha peak; then the river makes a great winding before it pierces through the Katuñ Alps, when it enters a wider valley, lying at an altitude of from 2000 to 3500 feet, which it follows until it emerges from the Altai highlands to join the Biya and to form the Ob by their confluence in a most picturesque region. The next valley is that of the Charysh, which has the Korgon and Tigeretsk Alps on one side and the Talitsk and Bashalatsk Alps on the other side. It is again very fertile, and is well peopled with Russian peasant immigrants in its lower parts. The Altai, seen from this valley, presents the most romantic scenes, including the small but deep Kolyvañ lake (altitude, 1180 feet), described by so many geographers, surrounded by fantastically-shaped granitic domes and towers. Farther west the valleys of the Uba, the Ulba, and the Bukhtarma open south-westwards towards the Irtysh. The lower part of the first is thickly populated; in the often-described valley of the Ulba is the Riddersk mine, at the foot of the 6770 feet high Ivanovsk peak, covered with beautiful alpine meadows. As to the valley of the Bukhtarma, which has a length of 200 miles, it also has its origin at the foot of the Byelukha and the Kuitun peaks, and as it falls from the 6195 feet high level of an alpine plateau to the Bukhtarma fortress (1130 feet) it offers the most striking contrasts of landscapes and vegetation. Its upper parts are rich in glaciers, the best known of which is the Berel, which flows from the double peak of the Byelukha. On the northern side of the mountain range which separates the upper Bukhtarma from the upper Katuñ one finds the Katuñ glacier, which, after two ice-falls, becomes from 700 to 900 yards wide, and is often described as the Altai *Mer de Glace*, while the Byelukha is described as the Altai Mont Blanc. From a grotto in this glacier wildly runs the Katuñ. The middle and lower parts of the Bukhtarma valley have been colonized since the 18th century by Russian peasant runaways—serfs and nonconformists—who had created there a free republic on Chinese territory; and after 1869, when this part of the valley was annexed to Russia, it was rapidly colonized, on account of the fertility of the wide prairies in its lower portion.

NORTH-EAST ALTAI.—The north-eastern Altai is much less known. High passes, of difficult access and over 10,000 feet of altitude, lead from it across the Sailughem to the Mongolian plateau; but they are seldom visited unless by Kirghiz shepherds. The high valleys of this portion of the Altai—Bashkaus, Chulyshman, and Chulcha, all three leading to the beautiful alpine lake Teletskoye (length, 117 miles; maximum width, 4 miles; altitude, 1600 feet) are only inhabited by nomad Telenguts. Even the shores of the lake—reminding one of the Lake of the Four Cantons—are too wild to receive a numerous population. From this lake issues the Biya, which becomes navigable only after it emerges from the mountains, *i.e.*, at Biysk. Sixty miles below this town it joins the Katuñ, and here begin the beautiful prairies in the north-west of the Altai.

KUZNETSK DISTRICT.—Farther to the north-east the Altai highlands are continued in the Kuznetsk district, which has a slightly different geological aspect, but still belongs to the Altai system. At the south-east limits of this district the Sayan range (from 6000 to 8000 feet, or more) appears as a continuation of the Sailughem, and has the same border-ridge character. But the Abakan river, which rises on its north-western slope, belongs to the system of the Yenisei. The Kuznetsk Alatau range, on the left bank of the Abakan, runs north-east into the province of Yeniseisk, while a complexus of imperfectly mapped mountains (Chukchut, Salairsk, Abakan, &c.) fills up the western portions of this territory. The Tom and its numerous tributaries rise on the northern slopes of the Alatau, and their fertile valleys are occupied by a thick Russian population, the centre of which is Kuznetsk, on the Tom.

Geology.—The geology of the Altai is yet imperfectly known. Granits, together with porphyry and porphyrite, intersected by veins of jade (veined porphyrite) and various breccias used for decorative purposes at the Kolyvañ stone-cutting works, as also diorites, diabases, augite porphyry, hyperstenite, &c., enter to a large extent into the composition of its mountains. The granites are very much decomposed, and take fantastic shapes round Lake Kolyvañ. Volcanic basalts and andesites are found in the Salair range. The great bulk of the mountains consists of various schists, limestones, sandstones, &c., belonging to the pre-Silurian period, the Silurian, Devonian, and Carboniferous ages; they are chiefly developed in the northern outer parts of the Altai. Since the Carboniferous period the Altai has not been under the sea, and its coal-bearing Jurassic deposits are of fresh-water origin; only in the Alatau are they of marine origin, and show that this part of the highland was partially invaded by the sea during the Secondary age. Numerous traces of an extended glaciation (including striated rocks) have been discovered by Prof. Sapozhnikoff. As a rule, the mountains are covered with thick diluvial deposits, and the forms of their granitic domes also suggest a wide glaciation.

Flora.—The flora of the Altai, explored chiefly by Ledebour, is rich and very beautiful. Up to a level of 1000 feet on the northern, and 2000 feet on the southern slopes, the flora is the habitual European flora which spreads in Siberia as far as the Yenisei. The steppe flora also penetrates from the south-west and drives the Altai flora to a still higher level. But above these levels up to 6000 feet, which is the average limit of tree vegetation, the mountains are covered with beautiful forests of birch, *Pinus cembra*, *Abies sibirica*, *Larix sibirica*, *Picea obovata*, and so on, while the meadows are clothed with a rich, brightly coloured, and typical covering of herbaceous plants. Even the alpine meadows, which have many species in common with the Alps, have a number of their own Altayan species.

Mineral wealth.—In respect of mineral wealth, the Altai proper is rich in silver, copper, lead, and zinc ores, while in the Alatau, gold, iron, and coal are the chief resources. The Alatau mines are only now beginning to be explored, while the copper, and perhaps also the silver ores of the Altai proper were already worked by the prehistoric "Chud," at a time when the use of iron was not yet known. Russians began to mine in 1727 at Kolyvañ, and in 1739 at Barnaul. But the Altai mines were made the property of the imperial family ("The Cabinet of His Majesty"), and the miners were made serfs, which they remained until 1861; and this circumstance hampered to a great extent both the development of mining and the colonization of the country. The ores of the Altai proper appear nearly always in the shape of irregular veins containing silver, lead, copper, and gold,—sometimes all together,—and they are worked chiefly at Zmeinogorsk (or Zmeieff), Zyryanovsk, Ust-Kamenogorsk, Riddersk (abandoned in 1861), and elsewhere. They offer, however, great difficulties, especially on account of their continually varying productivity and temperature of fusion. The beautiful varieties of porphyries—green, red, striped, &c.—which are obtained, often in big monoliths, near Kolyvañ, are cut at the imperial stone-cutting factory, whose produce is well known in the art galleries and palaces of Europe. Aquamarines of mediocre quality but enormous size (up to 3 inches in diameter) are found in the Korgon mine. The northern, or Salairsk, mining region also is rich in silver ores, and the mine of this name used formerly to yield up to 7776 ℔ of silver in one year. But the chief wealth of the north-east Altai is in the Kuznetsk coal-basin, also containing iron ores, which fills up a valley between the Alatau and the Salairsk range for a length of about 270 miles, with a width of about 65 miles, and is considered by Prof. Mushketoff as equal to the best coal basins of England and South Russia. Schmahlhausen's researches prove that these Coal Measures belong, like all those of East Siberia, Turkestan, &c., to the Jurassic formation. The country is also covered with thick diluvial and alluvial deposits containing gold. Gold is extracted in many places in the Altai; to the extent of 2887 kilograms in 1897. However, all the mining is now on the decline. Instead of the 36,000 ℔ of silver which used to be extracted, only 6060 ℔ were extracted in 1897. The yield of lead was 33,000 cwts. in 1868-71, and 20,000 cwts. in 1895; of copper, 4400 cwts. in 1897. Coal, however, is being extracted in small quantities.

Population.—The Russian agricultural population has rapidly increased since the fertile valleys belonging to the imperial family have been thrown open to immigration, and it is estimated that the present agricultural population of the region (Biysk, Barnaul, and Kuznetsk districts) already reaches about 800,000. The natives may represent a population of about 45,000. They are Altayans in the west and Telenghites in the east, with a few Kalmyks and Tatars. Although all called Kalmyks by the Russians, they speak a Turkish language. Both the Telenghites and the Altayans are Shamanists, but many of the former are already quite Russified. As to the virgin forests of the Kuznetsk Alatau—the Cherñ, or the Black Forest of the Russians,—they are peopled by Tatars (Chernevyie or Black Forest Tatars), who live in very small settlements, sometimes of the Russian type, but mostly in wooden *yurtas* of the Mongolian fashion. They can hardly keep any cattle, and live the poor life of forest-dwellers, feeding upon various wild roots, when there is no grain in the spring to be crushed with a hand-mill. Honey and cedar-nuts (from *Pinus cembra*) collected in the forests are much relied upon for buying grain from the Russians. Hunting and fishing are also resorted to, and the skins and furs are tanned by the family.

Agriculture.—The chief occupation of the Russians is agriculture (about 3,500,000 acres under culture), cattle breeding, bee culture (over 400,000 hives), mining, gathering of cedar-nuts (from 3000 to 10,000 cwts. yearly) and hunting. All this produce is exported partly to Tomsk and partly to Kobdo in Mongolia.

Towns.—The real capital of the Altai is Barnaul, the centre of the mining administration and altogether an animated commercial town (29,408 inh.); Biysk, which is the commercial centre (17,206 inh.); Kuznetsk (3140 inh.), Ust-Kamenogorsk (8958), and the mining towns Kolyvañ (11,703), Zmeinogorsk (6083), Riddersk (4000), and Salairsk (2500). Many villages are very populous.

Administration.—Most of the Altai region, covering an area of nearly 170,000 square miles and including the Kuznetsk region, forms a domain of the imperial family under the name of *Altai Mining District*.

AUTHORITIES.—RITTER's *Asien*, LEDEBOUR's *Reise*, TCHIKHATCHEFF's *Altai*, and COTTA's *Altai* are still very well worth consulting. Of modern works, *Zhivopisnaya Rossiya* ("Picturesque Russia"), vol. xi., by POTANIN, MUSHKETOFF, ADRIANOFF, and others; SEMENOFF's *Geographical Dictionary*; ADRIANOFF's "Journey to the Altai," in *Zapiski Russ. Geogr. Soc.* xi.; YADRINTSEFF's "Journey in West Siberia," in *Zapiski West Sib. Geogr. Soc.* ii.; GOLUBEFF's *Altai*, 1890 (Russian); SCHMURLO, "Passes in S. Altai" (Sailughem), *Izvestia Russ. Geogr. Soc.* 1898, xxxiv. 5; Prof. SAPOZHNIKOFF, various articles on glaciers, &c., in same periodical, 1897, xxxiii.; 1899, xxxv. (P. A. K.)

Altdorf, the capital of the Swiss canton of Uri, with a station on the St Gothard Railway, 22 miles from Goschenen and 34 miles from Lucerne. In 1899 a fine new carriage road was opened from Altdorf through the Schächenthal and over the Klausen Pass (6404 feet) to Linththal (30 miles from Altdorf), and so to Glarus. In 1895 a fine bronze statue of Tell and his son, by Kissling, was set up in the market-place. In 1899 a theatre, close to the town, was opened for the sole purpose of representing Schiller's *William Tell*. There is a stately parish church. Population in 1888, 2542; 1899, 2553; in 1900, 3134.

Altena, a town of Prussia, province Westphalia, 38 miles by rail S.S.E. from Dortmund. It has hardware (especially fine wire) industries, a castle, and a museum. Population (1885), 9387; (1895), 12,108; (1900), 12,769.

Altenburg, a town of Germany, capital of the duchy of Saxe-Altenburg, 23 miles S. from Leipsic by rail, with fine suburbs. A museum, with natural history, archæological, and art collections, has been erected, and there may be mentioned St. Bartholomew's church (1089), the German Renaissance town hall (1562-64), a lunatic asylum, teachers' seminary, and agricultural school. There are lignite mines in the vicinity. Population (1885), 29,110; (1895), 33,420; (1901), 37,110.

Altendorf, a commune of Prussia, in the Rhine province, 1 mile W. from Essen, with coal-mines and iron-works. It embraces the two colonies of Krupp's work-people—Kronenberg (population, 7764 in 1890) and Schederhof (4431). In 1901 it was incorporated with Essen. Population (1885), 25,693; (1895), 40,280; (1900), 63,271.

Altenessen, a commune of Prussia, in the Rhine province, 3 miles N. from Essen, with coal-mines, machinery factories, and lime-kilns. Population (1885), 15,599; (1895), 20,976; (1901), 27,938.

Alton, a city of Madison county, Illinois, U.S.A., situated in the western part of the state, on the eastern bank of Mississippi river, just above the mouth of Missouri river, and twenty-one miles above St Louis, at an altitude of 436 feet. It is built on the river bluffs, and its plan is fairly regular. It is entered by four railways. The population in 1880 was 8975, in 1890 it was 10,294, and in 1900 it was 14,210.

Altona, a town of Prussia, province Schleswig-Holstein, immediately W. of Hamburg, with which it is commercially identified, though administratively it is a separate town. Municipal offices, a bronze equestrian statue of the Emperor William I., and a bronze statue of Bismarck have been erected; there may also be noticed the public museum (containing ethnographical and natural history collections), and monuments of the wars of 1864 and 1870-71. Altona is the headquarters of the 9th German army corps, and possesses a school of navigation and famous fish-markets. Among its industries are the production of cottons, woollens, chemicals, chicory, hats, and varnish. Since 1888, when Altona joined the Imperial Zollverein, approximately half a million sterling has been spent upon harbour improvement works. The imports and exports resemble those of Hamburg (*q.v.*). In the ten years 1871-80 the port was entered on an average by 737 vessels of 67,735 tons, in 1881-90 by 608 vessels of 154,713 tons, and in 1891-98 by 839 vessels of 253,384 tons. In 1889 Ottensen (to the W. of Altona), where the poet Klopstock lies buried, was incorporated with the town. In 1885 (including Ottensen, Oevelgönne, Othmarschen, and Bahrenfeld) the population was 126,306; in 1895, 148,944; in 1900, 161,508; without the four suburbs, 113,526 (1895); 117,824 (1900).

Altoona, a city of Blair county, Pennsylvania, U.S.A., situated in 40° 32′ N. lat. and 78° 24′ W. long., at the foot of the Allegheny plateau, not far from the centre of the state, at an altitude of 1179 feet. It is on the main line of the Pennsylvania railway. The city is divided into nine wards, is regularly laid out, and is well built, having been in great part constructed by the railway corporation as its chief manufacturing depot. Fostered by the railway, it has had a very rapid and solid growth. The population in 1880 was 19,710, in 1890 it was 30,337, and in 1900 it was 38,973

Altrincham, or ALTRINGHAM, a market town and railway station in the Altrincham parliamentary division of Cheshire, England, 8 miles S.W. by S. of Manchester. The more recent structures are a Baptist chapel, a Unitarian chapel, and a market hall. Area of township (an urban district), 662 acres. Population (1881), 11,250; (1891), 12,440; (1901), 16,831; of parliamentary division (1901), 78,796.

Altwasser, an industrial village of Prussia, province Silesia, 43 miles by rail S.W. from Breslau, and 3 N. from Waldenburg. It has factories for glass, porcelain, machinery, cotton-spinning, iron-foundries, and coal-mines. Population (1885), 8672; (1895), 10,207; (1900), 12,700.

Altyn-tagh, or ASTYN-TAGH, a lofty mountain range of central Asia, running from the S.W. to the N.E., from 38° N.-87½° E. to 39° N.-91° E., forms a border range of Northern Tibet, having to the north-west the lower terrace of the East Turkestan plateau, about 2700 feet high on the banks of the Cherchen-daria, and to the south-east the north-western extremity of the Tsaidam plateau, nearly 10,000 feet of altitude. In 89° 30′ E. it is separated from the Tarim basin by a secondary chain, about 7200 feet high, but farther west it rises above the desert as a nearly vertical wall. The passes visited by Prjewalsky and Carey reach 10,140 and 13,000 feet respectively, the summit attaining from 12,000 to 14,000 feet. (See KUEN-LUN.)

Alt-Zabrze, a village of Prussia, province of Silesia, 5 miles by rail E. from Gleiwitz. It is in repute for its iron-works, coal-mines, manufactory of wire ropes, &c. Population (1885), 9390; (1895), 14,012; (1900), 19,571.

Aluminium.—Although never met with in the elemental state, the metal aluminium is more widely distributed throughout the world than any similar substance. The word is derived from the Latin *alumen*, and is probably akin to the Greek ἅλς (the root of *salt*, *halogen*, etc.); but while Pliny the Elder and other Roman authors discuss its properties at some length, there is considerable doubt whether the alum they knew was not largely composed of sulphate of iron. In the 16th century A.D., Paracelsus drew the first real distinction between alum and the vitriols; in 1722 Hoffmann announced the base of alum to be an individual substance; in 1761 Morveau suggested that this base should be called *alumine*, after *Sel alumineux*, the French name for alum; and finally about 1820 the word was changed into *alumina*. In 1760 the French chemist Baron unsuccessfully attempted "to reduce the base of alum" to a metal, and shortly afterwards various other investigators essayed the problem in vain. In 1808 Sir Humphry Davy, fresh from the electrolytic isolation of potassium and sodium, strove to break up the molecule of alumina by heating it with potash in a platinum crucible and submitting the mixture to a current of electricity; in 1809, with a more powerful battery, he raised iron wire to a red heat in contact with alumina, and obtained distinct evidence of the production of an iron-aluminium alloy. Naming the new metal in anticipation of its actual birth, he called it *alumium;* but for the sake of analogy he was soon persuaded to change the word to *aluminum*, in which form, alternately with *aluminium*, it occurs in chemical literature for some thirty years. The metal is occasionally called *aluminum* in America to this day; but the European spelling is preferable, as the termination *-ium* harmonizes with the names of other metallic elements.

Preparation.

In the year 1824, endeavouring to prepare it by chemical means, Oersted heated its chloride with potassium amalgam, and failed in his object simply by reason of the mercury, so that when Wöhler repeated the experiment at Gottingen in 1827, employing potassium alone as the reducing agent, he obtained it in the metallic state for the first time in history. Contaminated as it was with potassium and with platinum from the crucible, the metal formed a grey powder and was far from pure; but in 1845 he improved the conditions of his process, and succeeded in producing metallic globules wherewith he examined its chief properties, and prepared several compounds hitherto unknown. Early in 1854, H. St. Claire Deville, who was attempting to make some non-existent salts of aluminium, accidentally and in ignorance of Wöhler's later results, imitated the 1845 experiment. At once observing the reduction of the chloride, he realized the importance of his discovery, and immediately began to study methods for winning the metal on a commercial scale. His attention was at first divided between two processes—the chemical method of reducing the chloride with potassium, and an electrolytic method of decomposing it with a carbon anode and a platinum cathode, which was simultaneously imagined by himself and Bunsen. Both schemes appeared well-nigh impossible: potassium cost about £17 per ℔, gave a very small yield, and was dangerous to manipulate, while on the other hand, the only source of electric current then available was the primary battery, and zinc as a store of industrial energy was utterly out of the question. Deville accordingly returned to pure chemistry and invented a practicable method of preparing sodium which, having a lower atomic weight than potassium, reduced a larger proportion. He next devised a plan for manufacturing pure alumina from the natural ores, and finally elaborated a process and plant which held the field for almost thirty years. So admirably and exhaustively were his researches conducted that it required a Castner to improve on his methods. Only the discovery of dynamo-electric machines and their application to metallurgical processes rendered it possible for the brothers Cowles to remove the industry from the hands of chemists, till the time when Messrs. Héroult and Hall, by devising the electrolytic method now in use, placed the business finally under the control of electricians, and inaugurated the present era of industrial electrolysis.

Ores.

The chief natural compounds of aluminium are four in number: oxide, hydroxide (hydrated oxide), silicate, and fluoride. *Corundum*, the only important native oxide (Al_2O_3), occurs in large deposits in southern India and the United States. Although it contains a higher percentage of metal (52·9 per cent.) than any other natural compound, it is not at present employed as an ore, not only because it is so hard as to be crushed with difficulty, but also because its very hardness makes it valuable as an abrasive. *Cryolite* ($Al_2F_6 . 6NaF$) is a double fluoride of aluminium and sodium, which is scarcely known except on the west coast of Greenland. Formerly it was used for the preparation of the metal, but the inaccessibility of its source, and the fact that it is not sufficiently pure to be employed without some preliminary treatment, caused it to be abandoned in favour of other salts. When required in the Héroult-Hall process as a solvent, it is sometimes made artificially. Aluminium silicate is the chemical body of which all clays are nominally composed. *Kaolin* or *China clay* is essentially a pure disilicate ($Al_2O_3 . 2SiO_2 . 2H_2O$), occurring in large beds almost throughout the world, and containing in its anhydrous state 24·4 per cent. of the metal, which, however, in common clays is more or less replaced by calcium, magnesium, and the alkalis, the proportion of silica sometimes reaching 70 per cent. Kaolin thus seems to be the best ore, and it would undoubtedly be used were it not for the fatal objection that no satisfactory process has yet been discovered for preparing pure alumina from any mineral that is chemically a silicate. If, according to the present method of winning the metal, a bath containing silica as well as alumina is submitted to electrolysis, both oxides are dissociated, and as silicon is a very undesirable impurity, an alumina contaminated with silica is not suited for reduction. *Bauxite* is a hydrated oxide of aluminium of the ideal composition, $Al_2O_3 . 2H_2O$. It is a somewhat widely distributed mineral, being met with in Styria, Austria, Hesse, and French Guiana; but the most important beds are in the south of France, the north of Ireland, and in Alabama, Georgia, and Arkansas in North America. The chief Irish deposits are in the neighbourhood of Glenravel, Co. Antrim, and have the advantage of being near the coast, so that the alumina can be transported by water-carriage. After being dried at 100° C., Antrim bauxite contains from 33 to 60 per cent. of alumina, from 2 to 30 per cent. of ferric oxide, and from 7 to 24 per cent. of silica, the balance being titanic acid and water of combination. The American bauxites contain from 38 to 67 per cent. of alumina, from 1 to 23 per cent. of ferric oxide, and from 1 to 32 per cent. of silica. The French bauxites are of fairly constant composition, containing usually from 58 to 70 per cent. of alumina, 3 to 15 per cent. of foreign matter, and 27 per cent. made up of silica, iron oxide, and water in proportions that vary with the colour and the situation of the beds.

Before the application of electricity, only two compounds were found suitable for reduction to the metallic state. Alumina itself is so refractory that it cannot be melted save by the oxy-hydrogen blowpipe, or the electric arc, and except in the molten state it is not susceptible of decomposition by any chemical reagent. Deville first selected the chloride as his raw material, but observing it to be volatile and extremely deliquescent, he soon substituted in its place a double chloride of aluminium and sodium. Early in 1855 Percy suggested that cryolite should be more convenient, as it was a natural mineral and might not require purification, and at the end of March in that year, Faraday exhibited before the Royal Institution samples of the metal reduced from its fluoride by Dick and Smith. Rose also carried out experiments on the decomposition of cryolite, and expressed an opinion that it was the best of all compounds for reduction; but, finding the yield of metal to be low, receiving a report of the difficulties experienced in mining the ore, and fearing to cripple his new industry by basing it upon the employment of a mineral of such uncertain supply, Deville decided to keep to his chlorides. With the advent of the dynamo, the position of affairs was wholly changed. The first successful idea of using electricity depended on the enormous heating powers of the arc. The infusibility of alumina was no longer prohibitive, for the molten oxide is easily reduced by carbon. Nevertheless, it was found impracticable to smelt alumina electrically except in presence of copper, so that the Cowles furnace yielded, not the pure metal, but an alloy. So long as the metal was principally regarded as a necessary ingredient of aluminium-bronze, the Cowles process was popular, but when the advantages of aluminium itself became more apparent, there arose a fresh demand for some cheap method of obtaining it unalloyed. It was soon discovered that the faculty of inducing dissociation possessed by the current might now be utilized with some hope of pecuniary success, but as electrolytic currents are of lower voltage than those required in electric furnaces, molten alumina again became impossible. Many metals, of which copper, silver, and nickel are types, can be readily won or purified by the electrolysis of aqueous solutions, and theoretically it may be feasible to treat aluminium in an identical manner. In practice, however, it cannot be thrown down electrolytically with a dissimilar anode so as to win the metal, and certain difficulties are still met with in the analogous operation of plating by means of a similar anode. Of the simple compounds, only the fluoride is amenable to electrolysis in the fused state, since the chloride begins to volatilize below its melting-point, and the latter is only 5° below its boiling-point. Cryolite is not a safe body to electrolyse, because the minimum voltage needed to break up the aluminium fluoride is 4·0, whereas the sodium fluoride requires only 4·7 volts; if, therefore, the current rises in tension, the alkali is reduced, and the final product consists of an alloy with sodium. The corresponding double chloride is a far better material; first, because it melts at about 180° C., and does not volatilize below a red heat, and second, because the voltage of aluminium chloride is 2·3 and that of sodium chloride 4·3, so that there is a much wider margin of safety to cover irregularities in the electric pressure. It has been found, however, that molten cryolite and the analogous double fluoride represented by the formula $Al_2F_6 . 2NaF$ are very efficient solvents of alumina, and that these solutions can be easily electrolysed at about 800° C. by means of a current that completely decomposes the oxide but leaves the haloid salts unaffected. Molten cryolite dissolves roughly 30 per cent. of its weight of pure alumina, so that when ready for treatment the solution contains about the same proportion of what may be termed "available" aluminium as does the fused double chloride of aluminium and sodium. The advantages lie with the oxide because of its easier preparation. Alumina dissolves readily enough in aqueous hydrochloric acid to yield a solution of the chloride, but neither this solution, nor that containing sodium chloride, can be evaporated to dryness without decomposition. To obtain the anhydrous single or double chloride, alumina must be ignited with carbon in a current of chlorine, and to exclude iron from the finished metal, either the alumina must be pure, or the chloride be submitted to purification. Thus preparation of a chlorine compound suited for electrolysis becomes more costly and more troublesome than that of the oxide, and in addition four times as much raw material must be handled.

At different times propositions have been made by Bucherer, Blackmore, and others, to win the metal from its sulphide. This compound possesses a heat of formation so much lower that electrically it needs but a voltage of 0·9 to decompose it, and it is easily soluble in the fused sulphides of the alkali metals. It can also be reduced metallurgically by the action of molten iron. Various considerations, however, tend to show that there cannot be so much advantage in employing it as would appear at first sight. As it is easier to reduce than any other compound, so it is more difficult to produce. Therefore while less energy is absorbed in its final reduction, more is needed in its initial preparation, and it is questionable whether the economy possible in the second stage would not be neutralized by the greater cost of the first stage in the whole operation of winning the metal from bauxite with the sulphide as the intermediary.

Chemical reduction.

The Deville process as gradually elaborated between 1855 and 1859 exhibited three distinct phases:—Production of metallic sodium, formation of the pure double chloride of sodium and aluminium, and preparation of the metal by the interaction of the two former substances. To produce the alkali metal, a calcined mixture of sodium carbonate, coal, and chalk was strongly ignited in flat retorts made of boiler-plate; the sodium distilled over into condensers, and was preserved under heavy petroleum. In order to prepare pure alumina, bauxite and sodium carbonate were heated in a furnace until the reaction was complete; the product was then extracted with water to dissolve the sodium aluminate, the solution treated with carbon dioxide, and the precipitate removed and dried. This purified oxide, mixed with sodium chloride and coal tar, was carbonized at a red heat, and ignited in a current of dry chlorine as long as vapours of the double chloride were given off, these being condensed in suitable chambers. For the production of the final aluminium, 100 parts of the chloride and 45 parts of cryolite to serve as a flux were powdered together, and mixed with 35 parts of sodium cut into small pieces. The whole was thrown in several portions on to the hearth of a furnace previously heated to low redness, and was stirred at intervals for three hours. At length when the furnace was tapped a white slag was drawn off from the top, and the liquid metal beneath was received into a ladle and poured into cast-iron moulds. The process was worked out by Deville in his laboratory at the École Normale in Paris. Early in 1855 he conducted large-scale experiments at Javel in a factory lent him for the purpose, where he produced sufficient to show at the French Exhibition of 1855. In the spring of 1856 a complete plant was erected at La Glacière, a suburb of Paris, but becoming a nuisance to the neighbours, it was removed to Nanterre in the following year. Later it was again transferred to Salindres, where the manufacture was continued by Messrs. Pechiney till, after Deville's death in 1881, the advent of the present electrolytic process rendered it no longer profitable. Deville received much encouragement and pecuniary assistance from the French Academy, and also from the hands of Napoleon III., who, impressed with an aluminium medal struck in his honour, and with a baby-rattle presented to the infant Prince Imperial, conceived the idea of furnishing his Cuirassiers with aluminium armour and helmets. For over a year the Emperor defrayed Deville's expenses, and although the latter did not find it possible to gratify his patron's military aspirations, yet Napoleon III.'s generosity in assisting scientific research has borne much fruit both in the western and eastern hemispheres.

When Deville quitted the Javel works, two brothers named Tissier, formerly his assistants, who had devised an improved sodium furnace and had acquired a thorough knowledge of their leader's experiments, also left, and erected a factory at Amfreville, near Rouen, to work the cryolite process. This need not be described at length. It consisted simply in reducing cryolite with metallic sodium exactly as in Deville's chloride method, and it was claimed to possess various mythical advantages over its rival. Two grave disadvantages were soon obvious—the limited supply of ore, and, what was even more serious, the large proportion of silicon in the reduced metal. The Amfreville works existed some eight or ten years, but achieved no permanent prosperity. In 1858 or 1859 a small factory, the first in England, was built by F. W. Gerhard at Battersea, who also employed cryolite, made his own sodium, and was able to sell the product at 3s. 9d. per oz. This enterprise only lasted about four years. Between 1860 and 1874 Messrs Bell Brothers manufactured the metal at Washington, near Newcastle, under Deville's supervision, producing nearly 2 cwt. per year. They took part in the International Exhibition of 1862, quoting a price of 40s. per lb troy.

In 1881 Webster patented an improved process for making alumina, and the following year he organized the Aluminium Crown Metal Co. of Hollywood to exploit it in conjunction with Deville's method of reduction. Potash-alum and pitch were calcined together, and the mass was treated with hydrochloric acid; charcoal and water to form a paste were next added, and the whole was dried and ignited in a current of air and steam. The residue, consisting of alumina and potassium sulphate, was leached with water to separate the insoluble matter which was dried as usual. All the by-products, potassium sulphate, sulphur, and aluminate of iron, were capable of recovery, and were claimed to reduce the cost of the oxide materially. From this alumina the double chloride was prepared in essentially the same manner as practised at Salindres, but sundry economies accrued in the process owing to the larger scale of working and to the adoption of Weldon's method of regenerating the spent chlorine liquors. In 1886 Castner's sodium patents appeared, and The Aluminium Co. of Oldbury was promoted to combine the advantages of Webster's alumina and Castner's sodium. Castner had long been interested in aluminium, and was desirous of lowering its price. Seeing that sodium was the only possible reducing agent, he set himself to cheapen its cost, and deliberately rejecting sodium carbonate for the more expensive sodium hydroxide (caustic soda), and replacing carbon by a mixture of iron and carbon—the so-called carbide of iron—he invented the highly scientific method of winning the alkali metal which has remained in existence almost to the present day. In 1872 sodium prepared by Deville's process cost about 4s. per lb., the greater part of the expense being due to the constant failure of the retorts; in 1887 Castner's sodium cost less than 1s. per lb, for his cast-iron pots survived 125 distillations.

In the same year Graban patented a method of reducing the simple fluoride of aluminium with sodium, and his process was operated at Trothe in Germany. It was distinguished by the unusual purity of the metal obtained, some of his samples containing 99·5 to 99·8 per cent. In 1888 the Alliance Aluminium Co. was organized to work certain patents taken out during the previous year by Dr Netto, Capt. Cunningham, and Mr Fereter for winning the metal from cryolite by means of sodium, but these were only modifications in detail of the processes already described. This company erected plant in London, Hebburn, and Wallsend, and by 1889 were selling the metal at 11s. to 15s. per lb. The Aluminium Company's price in 1888 was 20s. per lb and the output about 250 lb per day. In 1889 the price was 16s., but by 1891 the electricians commenced to offer metal at 4s. per lb and aluminium reduced with sodium became a thing of the past.

Electrical reduction.

About 1879 dynamos began to be introduced into metallurgical practice, and from that date onwards numerous schemes for utilizing this cheaper form of energy were brought before the public. The first electrical method worthy of notice is that patented by Messrs E. H. and A. H. Cowles in 1885, which was worked both at Lockport, New York State, and at Milton, Staffordshire. The furnace consisted of a flat rectangular firebrick box, packed with a layer of finely powdered charcoal 2 inches thick. Through stuffing-boxes at the ends passed the two electrodes, made after the fashion of arc-light carbons, and capable of being approached together according to the requirements of the operation. The central space of the furnace was filled with a mixture of corundum, coarsely powdered charcoal, and copper; and an iron lid lined with firebrick was luted in its place to exclude air. The charge was reduced by means of a 50-volt current from a 300-kilowatt dynamo, which was passed through the furnace for 1½ hours till decomposition was complete. About 100 lb of bronze, containing from 15 to 20 lb of aluminium, were obtained from each run, the yield of the alloy being reported at about 1 lb per 18 e.h.p.-hours. The composition of the alloys thus produced could not be predetermined with exactitude; each batch was therefore analysed, a number of them were bulked together, or mixed with copper in the necessary proportion, and melted in crucibles to give merchantable bronzes containing between 1¼ and 10 per cent. of aluminium. Although the copper took no part in the reaction, its employment was found indispensable, as otherwise the aluminium partly volatilized, and partly combined with the carbon to form a carbide. It was also necessary to give the fine charcoal a thin coating of calcium oxide by soaking it in lime-water, for the temperature was so high that unless it was thus protected it was gradually converted into graphite, losing its insulating power and diffusing the current through the lining and walls of the furnace. That this process did not depend upon electrolysis, but was simply an instance of electrical smelting, or the decomposition of an oxide by means of carbon at the temperature of the electric arc, is shown by the fact that the Cowles furnace would work with an alternating current.

In 1883 Gratzel patented a useless electrolytic process with fused cryolite or the double chloride as the raw material, and in 1886 Kleiner propounded a cryolite method which was worked for a time by the Aluminium Syndicate at Tyldesley near Manchester, but was abandoned in 1890. In 1887 Minet took out patents for electrolysing a mixture of sodium chloride with aluminium fluoride, or with natural or artificial cryolite. The operation was continuous, the metal being regularly run off from the bottom of the bath, while fresh alumina and fluoride were added as required. The process exhibited several disadvantages; the electrolyte had to be kept constant in composition lest either fluorine vapours should be evolved or sodium thrown down, and the raw materials had accordingly to be prepared in a pure state. After prolonged experiments in a factory owned by Messrs Bernard Frères at St Michel in Savoy, Minet's process was given up, and at the close of the 19th century the Héroult-Hall method was alone being employed in the manufacture of aluminium throughout the world.

The original Deville process for obtaining pure alumina from bauxite was greatly simplified in 1889 by Bayer, whose most recent patents are being exploited at Larne in Ireland. Crude bauxite is ground, lightly calcined to destroy organic matter, and agitated under a pressure of 70 or 80 lb per square inch with a solution of sodium hydroxide having the specific gravity 1·45. After two or three hours the liquid is diluted till its density falls to 1·23, when it is passed through filter-presses to remove the insoluble ferric oxide and silica. The solution of sodium aluminate, containing aluminium oxide and sodium oxide in the molecular proportion of 8 to 1, is next agitated for thirty-six hours with a small quantity of hydrated alumina previously obtained, which causes the liquor to decompose, and some 70 per cent. of the aluminium hydroxide to be thrown down. The filtrate, now containing roughly two molecules of alumina to one of soda, is concentrated to the original gravity of 1·45, and employed instead of fresh caustic for the attack of more bauxite; the precipitate is then collected, washed till free from soda, dried, and ignited at about 1000° C. to convert it into a crystalline oxide which is less hygroscopic than the former amorphous variety.

The process of manufacture which now remains to be described was patented during 1886 and 1887 in the name of C. M. Hall in America, in that of P. V. L. Héroult in England and France. It would be idle to discuss to whom the credit of first imagining the method rightfully belongs, for probably this is only one of the many occasions when new ideas have been born in several brains at the same time. Hall, however, at once realized that his aim should be to win aluminium itself in an electrically warmed bath; for a while Héroult seemed undecided between the pure metal and an alloy, between internal and external heating. By 1888 Hall was at work on a commercial scale at Pittsburg, reducing German alumina; in 1891 the plant was removed to New Kensington for economy in fuel, and was gradually enlarged to 1500 h.p.; in 1894 a factory of 5000 h.p. driven by water was erected at Niagara Falls. In 1890 also the Hall process operated by steam power was installed at Patricroft, Lancashire, where the plant had a capacity of 300 lb per day, but by 1894 the turbines of the Swiss and French works ruined the enterprise. About 1897 the Bernard factory at St Michel passed into the hands of Messrs Pecbiney, the machinery soon being increased to 3000 h.p., and there, under the control of a firm that has been concerned in the industry almost from its inception, aluminium is being manufactured by the Hall process. In July 1888 the Société Métallurgique Suisse erected plant driven by a 500-h.p. turbine to carry out Héroult's alloy process, and at the end of that year the Allgemeine Elektricitäts Gesellschaft united with the Swiss firm in organizing the Aluminium Industrie Actien Gesellschaft of Neuhausen to manufacture the metal on a larger scale. Héroult and Kiliani then reverted to the plan of winning the metal alone, and gradually the alloy process was abandoned. At present (1900) about 4000 h.p. obtained from the Rhine are employed at Neuhausen, and about 2000 h.p. at Rheinfelden, while some 3000 h.p. are similarly used by the Société Electro-Métallurgique Française of La Praz near Modane. In 1895 the British Aluminium Company was founded to mine bauxite and manufacture alumina in Ireland, to prepare the necessary electrodes at Greenock, to reduce the aluminium at Foyers, and to refine and work up the metal into marketable shapes at the old Milton factory of the Cowles Syndicate, remodelled to suit modern requirements.

The river Foyers in Inverness-shire, which empties itself into Loch Ness, makes a total descent of 400 feet during the last 1¼ mile of its course, and forms two cascades 40 feet and 165 feet high respectively. From a point some distance above the upper fall an 8-feet tunnel has been drilled through the solid rock, bringing the water at a high level to the brow of the hill that slopes down to the loch, which it descends in steel tubes to drive the turbines at the bottom. Lest the natural river should fail in times of drought, water-rights over some 100 square miles of Inverness-shire have been acquired, and a masonry dam has been built across the southern end of the mountain valley (700 feet high) that contained Lochs Farline and Garth, so as to raise the water level and form one vast reservoir 5 miles long by ¾ mile wide holding 4000 million gallons—sufficient without any rainfall to propel the machinery for 100 days. By the end of 1899 plant equal to 7000 h.p. had been installed, some of it, however, being employed in the manufacture of calcium carbide. Each dynamo is carried on the same vertical shaft with its turbine, and runs at a speed of 150 revolutions per minute, developing 700 e.h.p., and giving a current of some 8000 amperes at 60 volts.

The Héroult cell consists of a square iron or steel box lined with carbon rammed and baked into a solid mass; at the bottom is a cast-iron plate connected with the negative pole of the dynamo, but the actual working cathode is undoubtedly the layer of already reduced and molten metal that lies in the bath. The anode is formed of a bundle of carbon rods suspended from overhead so as to be capable of vertical adjustment. The cell is filled up with cryolite, and the current is turned on till this is melted; then the pure powdered alumina is fed in continuously as long as the operation proceeds. The current is supplied at a tension of 3 to 5 volts per cell, passing through 10 or 12 in series; and it performs two distinct functions—(1) it overcomes the chemical affinity of the aluminium oxide; (2) it overcomes the resistance of the electrolyte, heating the liquid at the same time. As a part of the voltage is consumed in the latter duty, only the residue can be converted into chemical work, and as the theoretical voltage of the aluminium fluoride in the cryolite is 4·0, provided the bath is kept properly supplied with alumina, the fluorides are not attacked. It follows, therefore, except for mechanical losses, that one charge of cryolite lasts indefinitely, that the sodium and other impurities in it are not liable to contaminate the product, and that only the alumina itself need be carefully purified. The operation is essentially a dissociation of alumina into aluminium, which collects at the cathode, and into oxygen, which combines with the anodes to form carbon monoxide, the latter escaping and being burnt to carbon dioxide outside. Theoretically 36 parts by weight of carbon are oxidized in the production of 54 parts of aluminium; practically the anodes waste at the same rate at which metal is deposited. The current density is about 700 amperes per square foot of cathode surface, and the number of rods in the anode is such that each delivers 6 or 7 amperes per square inch of cross-sectional area. The working temperature lies between 750° and 850° C., and the actual yield is 1 lb of metal per 12 e.h.p. hours. The bath is heated internally with the current rather than by means of external fuel, because this arrangement permits the vessel itself to be kept comparatively cool; if it were fired from without, it would be hotter than the electrolyte, and no material suitable for the construction of the cell is competent to withstand the attack of nascent aluminium at high temperatures. Aluminium is so light that it is a matter requiring some ingenuity to select a convenient solvent through which it shall sink quickly, for if it does not sink, it short-circuits the electrolyte. The molten metal has a specific gravity of 2·54, that of molten cryolite saturated with alumina is 2·35, and that of the fluoride $Al_2F_6.2NaF$ saturated with alumina 1·97. The latter therefore appears the better material, and was originally preferred by Hall; cryolite, however, dissolves more alumina, and has been finally adopted by both inventors.

Properties.

Aluminium is a white metal with a characteristic tint which most nearly resembles that of tin; when impure, or after prolonged exposure to air, it has a slight violet shade. Its atomic weight is 27 (26·77, H=1, according to J. Thomsen). It is trivalent. The specific gravity of cast metal is 2·583, and of rolled 2·688 at 4° C. It melts at 626° C. (freezing-point 654·5°, Heycock and Neville). It is the third most malleable and sixth most ductile metal, yielding sheets 0·000025 inch in thickness, and wires 0·004 inch in diameter. When quite pure it is somewhat harder than tin, and its hardness is considerably increased by rolling. It is not magnetic. It stands near the positive end of the list of elements arranged in electromotive series, being exceeded only by the alkalis and metals of the alkaline earths; it therefore combines eagerly, under suitable conditions, with oxygen and chlorine. Its coefficient of linear expansion by heat is 0·0000222 (Richards) or 0·0000231 (Roberts-Austen) per 1° C. Its mean specific heat between 0° and 100° is 0·227, and its latent heat of fusion 100 calories (Richards). Only silver, copper, and gold surpass it as conductors of heat, its value being 31·33 (Ag=100, Roberts-Austen). Its electrical conductivity, determined on 99·6 per cent. metal, is 60·5 per cent. that of copper for equal volumes, or double that of copper for equal weights, and when chemically pure it exhibits a somewhat higher relative efficiency. The average strength of 98 per cent. metal is approximately shown by the following table:—

	Elastic Limit, tons per square inch.	Ultimate Strength, tons per square inch.	Reduction of Area per cent.
Cast	3	7	15
Sheet . . .	5½	11	35
Bars	6½	12	40
Wire	7·13	13·29	60

Weight for weight, therefore, aluminium is only exceeded in tensile strength by the best cast steel, and its own alloy, aluminium bronze. An absolutely clean surface becomes tarnished in damp air, an almost invisible coating of oxide being produced, just as happens with zinc; but this film is very permanent and prevents further attack. Exposure to air and rain also causes slight corrosion, but to nothing like the same extent as occurs with iron, copper, or brass. Commercial electrolytic aluminium of the best quality contains as the average of a large number of tests, 0·48 per cent. of silicon and 0·46 per cent. of iron, the residue being essentially aluminium itself. The metal in mass is not affected by hot or cold water, the foil is very slowly oxidized, while the amalgam decomposes rapidly. Sulphuretted hydrogen has no action upon it, therefore articles made of it are not blackened in foggy weather or in rooms where crude coal gas is burnt. To inorganic acids, except hydrochloric, it is highly resistant, ranking well with tin in this respect; but alkalis dissolve it quickly. Organic acids such as vinegar, common salt, the natural ingredients of food, and the various extraneous substances used as food preservatives, alone, or mixed together, dissolve traces of it if boiled for any length of time in a chemically clean vessel; but when aluminium utensils are submitted to the ordinary routine of the kitchen, being used to heat or cook milk, coffee, vegetables, meat, and even fruit, and are also cleaned frequently in the usual fashion, no appreciable quantity of metal passes into the food. Moreover, did it do so, the action upon the human system would be infinitely less harmful than similar doses of copper or of lead.

The highly electro-positive character of aluminium is most important. At elevated temperatures the metal decomposes nearly all other metallic oxides, wherefore it is most serviceable as a metallurgical reagent. In the casting of iron, steel, and brass, the addition of a trifling proportion (0·005 per cent.) removes oxide, and renders the molten metal more fluid, causing the finished products to be more homogeneous, free from blow-holes, and solid all through. On the other hand, its electro-positive nature necessitates some care in its utilization. If it be exposed to damp, to sea-water, or to corrosive influences of any kind in contact with another metal, or if it be mixed with another metal so as to form an alloy which is not a true chemical compound, the other metal being highly negative to it, powerful galvanic action will be set up, and the structure will quickly deteriorate. This explains the failure of boats built of commercially pure aluminium which have been put together with iron or copper rivets, and the decay of other boats built of a light alloy, in which the alloying metal (copper) has been injudiciously chosen. It also explains why aluminium is so difficult to join with low-temperature solders, for these mostly contain a large proportion of lead. This disadvantage, however, is often overestimated, since in most cases other means of uniting two pieces are available.

Alloys. The metal produces an enormous number of useful alloys, some of which, containing only 1 or 2 per cent. of other metals, combine the lightness of aluminium itself with far greater hardness and strength. Some with 90 to 99 per cent. of other metals exhibit the general properties of those metals conspicuously improved. Among the heavy alloys, the aluminium bronzes (Cu, 90-97·5 per cent.; Al, 2·5-10 per cent.) occupy the most important position, showing mean tensile strengths increasing from 20 to 41 tons per square inch as the percentage of aluminium rises, and all strongly resisting corrosion in air or sea-water. The light copper alloys, in which the proportions just given are practically reversed, are of considerably less utility, for although they are fairly strong, they lack power to resist galvanic action. This subject is far from being exhausted, and it is not improbable that the alloy-producing capacity of aluminium may eventually prove its most valuable characteristic. In the meantime, ternary light alloys appear the most satisfactory, and tungsten and copper, or tungsten and nickel, seem to be the best substances to add.

Uses. The uses of aluminium are too numerous to mention. Probably the widest field is still in the purification of iron and steel. To the general public it appeals most strongly as a material for constructing cooking utensils. It is not brittle like porcelain and cast iron, not poisonous like lead-glazed earthenware and untinned copper, has no enamel to chip off like steel, does not rust and wear out like cheap tinplate, and weighs but a fraction of other substances. It is largely replacing brass and copper in all departments of industry—especially where dead weight has to be moved about, and lightness is synonymous with economy—for instance, in bed-plates for torpedo-boat engines, internal fittings for ships instead of wood, complete boats for portage, motor-car parts, and boiling-pans for confectionery and in chemical works. The British Admiralty employ it to save weight in the Navy, and the Continental war-offices equip their soldiers with it wherever possible. As a substitute for Solenhofen stone it is used in a modified form of lithography, which can be performed on rotary printing-machines at a high speed. With the increasing price of copper, it is coming into vogue as an electrical conductor for uncovered mains; it is found that an aluminium wire 0·126 inch in diameter will carry as much current as a copper wire 0·100 inch in diameter, while the former weighs about 79 ℔ and the latter 162 ℔ per mile. Assuming the materials to be of equal tensile strength per unit of area—hard-drawn copper is stronger, but has a lower conductivity—the adoption of aluminium thus leads to a reduction of 52 per cent. in the weight, a gain of 60 per cent. in the strength, and an increase of 26 per cent. in the diameter of the conductor; a saving in cost of poles is also effected. At present prices (1900) it is already cheaper than copper per unit of electric current conveyed; but when insulation is necessary, the smaller size of the copper wire renders it more economical. Aluminium conductors have been employed on heavy work in many places outside England, notably for a 30,000 volt current in Washington Territory, U.S.A., which is transmitted a distance of over 30 miles, and similar developments are proceeding in England, the earliest being at Northallerton. For telegraphy and telephony, aluminium conductors are in frequent demand, and give perfect satisfaction. Difficulties were at first encountered in making the necessary joints, but they have been largely overcome by practice and experience.

Two points connected with this metal are of sufficient moment to demand a few words by way of conclusion. Its extraordinary lightness forms its chief claim to general adoption, yet is apt to cause mistakes when its price is mentioned. It is the weight of a mass of metal which governs its financial value; its industrial value, in the vast majority of cases, depends on the volume of that mass. Provided it be rigid, the bed-plate of an engine is no better for weighing 30 cwt. than for weighing 10 cwt. A saucepan is required to have a certain diameter and a certain depth in order that it shall hold a certain bulk of liquid: its weight is merely an encumbrance. Copper being 3½ times as heavy as aluminium, whenever the latter costs less than 3½ times as much as copper it is actually cheaper. It must be remembered, too, that electrolytic aluminium has only been known during the last decade of the 19th century. Samples dating from the old sodium days are still in existence, and when they exhibit unpleasant properties the defect is often ascribed to the metal instead of to the process by which it was won. Much has yet to be learnt about the practical qualities of the electrolytic product, and although every day's experience serves to place the metal in a firmer industrial position, a final verdict can only be passed after the lapse of time. The individual and collective influence of the several impurities which occur in the product of the Héroult cell is still to seek, and the importance of this inquiry will be seen when we consider that if cast iron, wrought iron, and steel, the three totally distinct metals included in the generic name of "iron"—which are only distinguished one from another chemically by minute differences in the proportion of certain non-metallic ingredients—had only been in use for some dozen years, attempts might occasionally be made to forge cast iron, or to employ wrought iron in the manufacture of edge-tools. (E. J. R.)

Alva, a police burgh and (woollen) manufacturing town of Clackmannanshire (transferred from Stirlingshire, 1891), Scotland, 7 miles E. of Stirling, the terminus of a branch of the North British Railway. Population (1881), 4961; (1891), 5225; (1901), 4624.

Alverstone, Richard Everard Webster, 1st Baron, Lord Chief Justice of England (1842-——), was born 22nd December 1842, being the second son of Thomas Webster, Q.C. He was educated at King's College and Charterhouse schools, and Trinity College, Cambridge; was called to the bar in 1868, and became Q.C. only ten years afterwards. His practice was chiefly in commercial, railway, and patent cases until (June 1885) he was appointed attorney-general in the Conservative Government in the exceptional circumstances of never having been solicitor-general, and not at the time occupying a seat in parliament. He was elected for Launceston in the following month, and in November exchanged this seat for the Isle of Wight, which he continued to represent until his elevation to the House of Lords. Except under the brief Gladstone administration of 1886, and the Gladstone-Rosebery Cabinet of 1892-95, Sir Richard Webster was attorney-general from 1885 to 1899. In 1890 he was leading counsel for the *Times* in the Parnell inquiry; in 1893 he represented Great Britain in the Bering Sea arbitration; and in 1898 he discharged the same function in the matter of the boundary between British Guiana and Venezuela. He was well known as an athlete in his earlier years, having represented his university as a runner, and his interest in cricket and foot-racing was kept up in later life. In the House of Commons, and outside it, he was throughout his political career prominently associated with Church work; and though he had no claim to a reputation for eloquence, his speeches were distinguished for the more solid qualities of gravity and earnestness. In 1899 he succeeded Sir Nathaniel Lindley as Master of the Rolls, at the same time being raised to the peerage as Baron Alverstone, and in October of the same year he was elevated to the office of Lord Chief Justice upon the death of Lord Russell of Killowen.

Alwár, or Ulwar, a native state of India, in the Rajputana agency. Area, 3051 square miles; population (1881), 682,926; (1891), 767,786—average density, 252 persons per square mile; (1901), 828,888, showing an increase of 8 per cent. When compared with a heavy decrease elsewhere throughout Rajputana, this increase may be attributed to the successful administration of famine relief, under British officials. The gross revenue in 1896-97 was Rs.27,88,410, of which Rs.20,48,000 was derived from land, Rs.1,25,000 from salt, and Rs.1,85,000 from interest. The expenditure included Rs.3,59,000 for public works, Rs.5,10,706 for imperial service troops, Rs.3,87,602 for irregular forces, Rs.1,53,000 for palace, and Rs.3,13,000 for stables, &c. There was a balance of Rs.65,53,000, mostly invested in government securities. The present Maharaja, Jai Singh, who succeeded in 1892, was educated at the Mayo College, where he excelled both in sports and in knowledge of English. Alwár was the first native state to accept a currency struck at the Calcutta mint, of the same weight and assay as the imperial rupee, with the head of the British Sovereign on the obverse. Imperial service troops are maintained, consisting of both cavalry and infantry, with transport. The state is traversed by the Delhi branch of the Rajputana railway. A settlement of the land revenue is being carried out by an English civilian.

The city of ALWÁR is situated in 27° 34′ lat. N. and 76° 38′ E. long.; railway station on the Rajputana line, 98 miles from Delhi. Population (1881), 49,876; (1891), 52,398; (1901) 56,740, showing a steady increase. It stands in a valley overhung by a fortress 1000 feet above. It is surrounded by a rampart and moat, with five gates, and contains fine palaces, temples, and tombs. The water-supply is brought from a lake 9 miles distant. It has a high school, affiliated to the Allahabad university; and a school for the sons of nobles, founded to commemorate the Diamond Jubilee of Queen Victoria. The Lady Dufferin hospital is under the charge of an English lady doctor, with two female assistants.

Amakusa, an island belonging to Japan, 36½ miles long and 13½ wide, situated in 32° 20′ N. lat. and 131° E. long., on the west of the province of Higo, from which it is separated by the Yatsushiro-kai. It has no high mountains, but its surface being very hilly—four of the peaks rise to a height of over 1500 feet—the natives resort to the terrace system of cultivation with remarkable success. A number of the heads of the Christians executed in connexion with the Shimabara rebellion in the 17th century were buried in this island. Amakusa produces fine kaolin, which was largely used in former times by the potters of Hirado and Satsuma.

Amalfi, a town and archiepiscopal see of Campania, province of Salerno, Italy, on the N. coast of the Gulf of Salerno, 13 miles W. by S. from Salerno. This part of the coast produces first-class lemons. Macaroni is manufactured. A serious landslip choked up the harbour in January 1900. Population, 4792 (1881); 7329 (1901).

Amara, a town of Asiatic Turkey, in the Basra viláyet, on the left bank of the Tigris, connected with the right bank by a bridge of boats. It is the chief town of a rich district and exports grain and dates. Population, 9500.

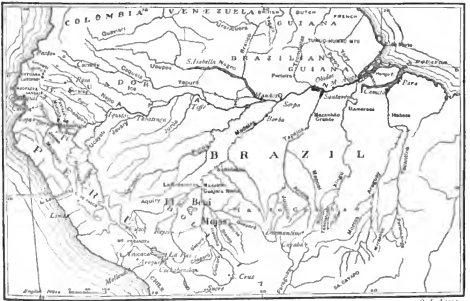
Amarapura, formerly capital of Burma, now a subdivision of the Mandalay district, with an area of 304 square miles and a population of 62,310. The old city of Amarapura is in a state of utter ruin. The Burmans know it as Myohrung, "the old city." It is a station on the Rangoon-Mandalay railway, and is the junction for the line to Maymyo and the Kunlông ferry, and for the Sagaing-Myitkyina railway. The group of villages called Amarapura by Europeans is known to the Burmans as Taung-myo, "the southern city," as distinguished from Mandalay, the Myauk-myo, or "northern city," 3 miles distant. Amarapura, though little more than a century old and abandoned so recently as 1860, is stamped with the desolation of ages, so completely have the climate and vandalism changed its aspect. It contains many pagodas.

Amásia, the chief town of a district in the Sivas viláyet in Asia Minor, and an important trade centre on the Samsún-Sivas road. It was one of the chief towns of the kingdom of Trebizond, and was much favoured by the early Osmanli sultans, one of whom, Selim I., was born there. Amásia has extensive orchards and fruit gardens; and there are steam flour-mills. Wheat, flour, and silk are exported. In 1895 there was a massacre of Armenians. Population, 30,000 (Moslems, 20,000, of whom one-third are Shíás; Christians, 10,000).

Amazon.—The river Amazon, the largest in the world, has a drainage area of 2,722,000 square miles, if the Tocantins be included in its basin. It drains four-tenths of South America, and it gathers its waters from 5° N. to 20° S. latitude. Its most remote sources are found on the inter-Andean plateau, but a short distance from the Pacific Ocean; and, after a course of about 4000 miles through the interior of Peru and across Brazil, it enters the Atlantic Ocean on the equator. It is generally accepted by geographers that the Marañon, or Upper Amazon, rises in the little lake, Lauricocha, in 10° 30′ S. latitude, and 100 miles N.N.E. of Lima. They appear to have followed the account given by Padre Fritz, which has since been found incorrect. According to Antonio Raimondi, it is the Rio de Nupe branch of the small stream which issues from the lake that has the longer course and the greater volume of water. The Nupe rises in the Cordillera de Huayhuath, and is the true source of the Marañon. There is a difference among geographers as to where the Marañon ends and the Amazon commences, or whether both names apply to the same river. The Pongo de Manseriche, at the base of the Andes, and the head of useful navigation, seems to be the natural terminus of the Marañon; and an examination of the hydrographic conditions of the great valley makes the convenience and accuracy of this apparent. Raimondi terminates the Marañon at the mouth of the Ucayali, Reclus the same, both following the missionary fathers of the colonial period. M. de la Condamine uses "Amazon" and "Marañon" indiscriminately, and considers them one and the same. Smith and Lowe give the mouth of the Javary as the eastern limit, as does d'Orbigny. Wolf, apparently uncertain, carries the "Marañon or Amazon" to the Peruvian frontier of Brazil, at Tabatinga. Other travellers and explorers contribute to the confusion. This probably arises from the rivalry of the Spaniards and Portuguese. The former accepted the name Marañon, in Peru, and as the missionaries penetrated the valley they extended the name until they reached the Ucayali; while, as the Portuguese ascended the Amazon, they carried its name to the extent of their explorations. Beginning with the lower river we propose to notice, first, the great affluents which go to swell the volume of the main stream.

Tributaries.

The **Tocantins** is not really a branch of the Amazon, although usually so considered. It is the great central fluvial artery of Brazil, running from south to north for a distance of about 1500 miles. It rises in the mountainous district known as the Pyreneos; but its more ambitious western affluent, the Araguay, has its extreme southern headwaters on the slopes of the Serra Cayapó, and flows a distance of 1080 miles before its junction with the parent stream, which it appears almost to equal in volume. Besides its main tributary, the Rio das Mortes, it has twenty smaller branches, offering many miles of canoe navigation. In finding its way to the lowlands, it breaks frequently into falls and rapids, or winds violently through rocky gorges, until, at a point about 100 miles above its junction with the Tocantins, it saws its way across a rocky dyke, for 12 miles, in roaring cataracts. The tributaries of the Tocantins, called the Maranhão and Parana-tinga, collect an immense volume of water from the highlands which surround them, especially on the south and south-east. Between the latter and the confluence with the Araguay, the Tocantins is occasionally obstructed by rocky barriers which cross it almost at a right angle. Through these, the river carves its channel, broken into cataracts and rapids, or *cachoeiras*, as they are called throughout Brazil. Its lowest one, the Itaboca cataract, is about 130 miles above its estuarine port of Cametá, for which distance the river is navigable; but above that it is useless as a commercial avenue, except for laborious and very costly transportation. The flat, broad valleys, composed of sand and clay, of both the Tocantins and its Araguay branch, are overlooked by steep bluffs. They are the margins of the great sandstone plateaux, from 1000 to 2000 feet elevation above sea-level, through which the rivers have eroded their deep beds. Around the estuary of the Tocantins the great plateau has disappeared, to give place to a part of the forest-covered, half-submerged alluvial plain which extends far to the north-east and west. The Pará river, generally called one of the mouths of the Amazon, is only the lower reach of the Tocantins. If any portion of the waters of the Amazon runs round the southern side of the large island of Marajo into the river Pará, it is only through tortuous, natural canals, which are in no sense outflow channels of the Amazon.



B V. Darbishire & O.J.R. Howarth

The Amazon and its Tributaries.

Oxford 1908

The **Xingú**, the next large river west of the Tocantins, is a true tributary of the Amazon. It was but little known until it was explored in 1884-87 by von den Steinen, from Cuyabá. Travelling east, 240 miles, he found the river Tamitatoaba, 180 feet wide, flowing from a lake 25 miles in diameter. He descended this torrential stream to the river Romero, 1300 feet wide, entering from the west, which receives the river Colisú. These three streams form the Xingú, or Parana-xingú, which, from 73 miles lower down, bounds along a succession of rapids for 400 miles. A little above the head of navigation, 105 miles from its mouth, the river makes a bend to the east to find its way across a rocky barrier. Here is the great cataract of Itamaracá, which rushes down an inclined plane for 3 miles and then gives a final leap, called the Fall of Itamaracá. Near its mouth, the Xingû expands into an immense lake, and its waters then mingle with those of the Amazon through a labyrinth of *caños* (natural canals), winding in countless directions through a wooded archipelago.

The **Tapajos**, running through a humid, hot, and unhealthy valley, pours into the Amazon 500 miles above Pará, and is about 1200 miles long. It rises on the lofty Brazilian plateau near Diamantino, in 14° 25′ S. lat. Near this place, a number of streams unite to form the river Arinos, which, at latitude 10° 25′, joins the Juruena, to form the "Alto Tapajos," so called as low down as the Rio Manoel, entering from the east. Thence, to Santarem, the stream is known as the Tapajos. The lower Arinos, the Alto Tapajos, and the Tapajos to the last rapid, the Maranhão Grande, is a continuous series of formidable cataracts and rapids; but from the Maranhão Grande to its mouth, about 188 miles, the river can be navigated by large vessels. For its last 100 miles, it is from 4 to 9 miles wide, and much of it very deep. The valley of the Tapajos is bordered on both sides by bluffs. They are from 300 to 400 feet high along the lower river; but, a few miles above Santarem, they retire from the eastern side and only approach the Amazon flood-plain some miles below Santarem.

The **Madeira** has its junction with the Amazon 870 miles by river above Pará, and almost rivals it in the volume of its waters. It rises over 50 feet during the rainy season, and the largest ocean steamers may ascend it to the Fall of San Antonio, 663 miles above its mouth; but in the dry months, from June to November, it is only navigable, for the same distance, for craft drawing from 5 to 6 feet of water. According to the treaty of San Ildefonso, the Madeira commences at the confluence of the Guaporé with the Mamoré. Both of these streams have their headwaters almost in contact with those of the river Paraguay. The idea of a connecting canal is based on ignorance of local conditions. San Antonio is the first of a formidable series of cataracts and rapids, nineteen in number, which, for a river distance of 263 miles, obstruct the upper course of the Madeira until the last rapid, called Guajará Merim (or Small Pebble), is reached, a little below the union of the Guaporé with the Mamoré. The junction of the great river Beni with the Madeira is at the "Madeira" Fall, a vast and grand display of reefs, whirlpools, and boiling torrents. Between Guajará-Merim and this fall, inclusive, the Madeira receives the drainage of the north-eastern slopes of the Andes, from Santa Cruz de la Sierra to Cuzco, the whole of the south-western slope of Brazilian Matto-grosso, and the northern one of the Chiquitos sierras, an area about equal to that of France and Spain. The waters find their way to the falls of the Madeira by many great rivers, the principal of which, if we enumerate them from east to west, are the Guaporé or Itenez, the Baures or Blanco, the Itonama or San Miguel, the Mamoré, Beni and Mayu-tata, or Madre de Dios, all of which are reinforced by numerous secondary, but powerful affluents. The Guaporé presents many difficulties to continuous navigation; the Baures and Itonama offer hundreds of miles of navigable waters through beautiful plains; the Mamoré has been sounded by the writer, in the driest month of the year, for a distance of 500 miles above Guajará-Merim, and found never less than from 10 to 30 feet of water, with a current of from 1 to 3 miles an hour. Its Rio Grande branch, explored under the writer's instructions, was found navigable for craft drawing 3 feet of water to within 30 miles of Santa Cruz de la Sierra—a level sandy plain intervening. The Grande is a river of enormous length, rising in a great valley of the Andes between the important cities of Sucre and Cochabamba, and having its upper waters in close touch with those of the Pilcomayo branch of the great river Paraguay. It makes a long curve through the mountains, and, after a course of about 800 miles, joins the Mamoré near 15° S. lat. The Chaparé, Securé, and Chimoré, tributaries of the Mamoré, are navigable for launches up to the base of the mountains, to within 130 miles of Cochabamba. The Beni has a fall, 18 miles above its mouth, called "La Esperanza"; beyond this, it is navigable for 217 miles to the port of Reyes for launches in the dry season, and larger craft in the wet one. The extreme source of the Beni is the little river La Paz, which rises in the inter-Andean region, a few miles south-east of Lake Titicaca, and flows as a rivulet through the Bolivian city of La Paz. From this point to Reyes, the river is a torrent. The principal affluent of the Beni, and one which exceeds it in volume, enters it 120 miles above its mouth, and is known to the Indians along its banks as the Mayu-tata. Its ramifications drain the slopes of the Andes between 12° and 15° of latitude. It was long thought to be a tributary of the Purús, until the ill-fated Maldonado demonstrated that it belonged to the Madeira river system. It is navigable, in the wet season, to the base of the Andes, to within 180 miles of Cuzco. Its upper waters are separated by only a short transitable portage from those of the Ucayali. When, however, the river is low, it is obstructed by several shoals, and violent, but surmountable currents, and its middle course has two rapids, each with the usual "head, body, and tail." It has sixty-three islands, great and small, from its mouth to its principal affluent, the Inambari, which joins it from the south, flowing along the base of the Andes. Its bed is definitively formed, its banks are solid, and the country it traverses is picturesque and frequently of exceeding beauty. All of the upper branches of the river Maderia find their way to the falls across the open, almost level Mojos and Beni plains, 35,000 square miles of which are yearly flooded to an average depth of about 3 feet, for a period of from three to four months. They rival if they do not exceed in fertility the valley of the Nile, and are the healthiest and most inviting agricultural and grazing region of the basin of the Amazon.

The **Purús**, a very sluggish river, enters the Amazon west of the Madeira, which it parallels as far south as the falls of the latter stream. It runs through a continuous forest at the bottom of the great depression lying between the Madeira river, which skirts the edge of the Brazilian sandstone plateau, and the Ucayali, which hugs the base of the Andes. Chandless found its elevation above sea-level to be only 107 feet 590 miles from its mouth. It is one of the most crooked streams in the world, and its length, in a straight line, is less than half that by its curves. It is practically only a drainage ditch for the half-submerged, lake-flooded district it traverses. Its width is very uniform for 1000 miles up, and, for 800 miles, its depth is never less than 45 feet. It is navigable by steamers for 1648 miles as far as the little stream, the Curumahá, but only by light-draft craft. Chandless ascended it 1866 miles. At 1792 miles, it forks into two small streams. Occasionally a cliff touches the river, but in general the lands are subject to yearly inundations throughout its course, the river rising at times above 50 feet, the numerous lakes to the right and left serving as reservoirs. Its main tributary, the Aquiry or Acre, enters from the right about 1104 miles from the Amazon. Its sources are near those of the Mayu-tata. It is navigable for a period of about five months of the year, when the Purús valley is inundated;

and, for the remaining seven months, only canoes can ascend it sufficiently high to communicate overland with the settlements in the great india-rubber districts of the Mayu-tata and lower Beni: thus these regions are forced to seek a canoe outlet for their rich products by the very dangerous, costly, and laborious route of the falls of the Madeira.

The **Juruá** is the next great southern affluent of the Amazon west of the Purús, sharing with this the bottom of the immense inland Amazon depression, and having all the characteristics of the Purús as regards curvature, sluggishness, and general features of the low, half-flooded forest country it traverses. It rises among the Ucayali highlands, and is navigable and unobstructed for a distance of 1133 miles above its junction with the Amazon.

The **Javary**, the boundary line between Brazil and Peru, is another Amazon tributary of importance. It is supposed to be navigable, by canoe, for 900 miles above its mouth to its sources among the Ucayali highlands, but only 260 have been found suitable for steam navigation. The Brazilian Boundary Commission ascended it, in 1866, to the junction of the Shino with its Jaquirana branch. The country it traverses in its extremely sinuous course is very level, similar in character to that of the Juruá, and is a forested wilderness occupied by a few savage hordes.

The **Ucayali**, which rises only about 70 miles north of Lake Titicaca, is the most interesting branch of the Amazon next to the Madeira. Peru has fitted out many costly and ably-conducted expeditions to explore it. One of them (1867) claimed to have reached within 240 miles of Lima, and the little steamer *Napo* forced its way up the violent currents for 77 miles above the junction with the Pachitea river as far as the river Tambo, or Apurimac, 770 miles from the confluence of the Ucayali with the Amazon. The *Napo* then succeeded in ascending the Urubamba branch of the Ucayali 35 miles above its union with the Tambo, to a point 200 miles north of Cuzco. The remainder of the Urubamba, as shown by Bosquet in 1806, and Castelnau in 1846, is interrupted by cascades, reefs, and numberless other obstacles to navigation. The Tambo, which rises in the Vilcanota knot of mountains south of Cuzco, is a torrential stream valueless for commercial purposes. The banks of the Ucayali for 500 miles up are low, and, in the rainy season, extensively inundated.

The **Huallaga**, which joins the Amazon to the west of the Ucayali, rises high among the mountains, in about 10° 30′ S. lat., on the slopes of the celebrated Cerro de Pasco. For nearly its entire length, it is an impetuous torrent running through a succession of gorges. It has forty-two rapids, its last obstruction being the Pongo de Aguirre, so called from the traitor Aguirre, who passed there. To this point, 140 miles from the Amazon, the Huallaga can be ascended by large river steamers. Between the Huallaga and the Ucayali lies the famous "Pampa del Sacramento," a level region of stoneless alluvial lands covered with thick, dark forests, first entered by the missionaries in 1726. It is about 300 miles long, from north to south, and varies in width from 40 to 100 miles. Many streams, navigable for canoes, penetrate this region from the Ucayali and the Huallaga. It is still occupied by savage tribes.

The river **Marañon** rises about 100 miles to the north-east of Lima. It flows through a deeply-eroded Andean valley, in a north-west direction, along the eastern base of the Cordillera of the Andes, as far as 5° 36′ S. lat.; then it makes a great bend to the north-east, and with irresistible power cuts through the inland Andes, until, at the Pongo de Manseriche, it victoriously breaks away from the mountains to flow onwards through the plains under the name of the Amazon. Barred by reefs, and full of rapids and impetuous currents, it cannot become a commercial avenue. At the point where it makes its great bend, the river Chinchipe pours into it from southern Ecuador. Just below this, the mountains close in on either side of the Marañon, forming narrows or *pongos*, for a length of 35 miles, where, besides numerous whirlpools, there are no less than thirty-five formidable rapids, the series concluding with three cataracts just before reaching the river Imasa, or Chunchunga, near the mouth of which La Condamine embarked, in the 18th century, to descend the Amazon. Here, the general level of the country begins to decrease in elevation, with only a few mountain spurs, which, from time to time, push as far as the river and form *pongos* of minor importance, and less dangerous to descend. Finally, after passing the narrows of Guaracayo, the *cerros* gradually disappear, and, for a distance of about 20 miles, the river is full of islands, and there is nothing visible from its low banks but an immense forest-covered plain. But the last barrier has yet to be passed, the Pongo de Manseriche, 3 miles long, just below the mouth of the Rio Santiago, and between it and the old abandoned missionary station of Borja, in 38° 30′ S. lat. and 77° 30′ 40″ W. long. According to Captain Carbajal, who descended it in the little steamer *Napo* in 1868, it is a vast rent in the Andes about 2000 feet deep, narrowing in places to a width of only 100 feet, the precipices "seeming to close in at the top." Through this dark cañon, the Marañon leaps along, at times, at the rate of 12 miles an hour.[1] From the northern slope of its basin, the Amazon receives many tributaries, but their combined volume of water is not nearly so great as that contributed to the parent stream by its affluents from the south. That part of Brazil lying between the Amazon and French, Dutch, and British Guiana, and bounded on the west by the Rio Negro, is known as Brazilian Guiana. It is the southern watershed of a tortuous, low chain of mountains running, roughly, east and west. Their northern slope, which is occupied by the three Guianas first named, is saturated and river-torn; but their southern one, Brazilian Guiana, is in general thirsty and semi-barren, and the driest region of the Amazon valley. It is an area which has been left almost in the undisturbed possession of nomadic Indian tribes, whose scanty numbers find it difficult to solve the food problem. From the *divortium aquarum* between French Guiana and Brazil, known as the Tumuc-humac range of highlands, two minor streams, the Yary and the Paron, reach the Amazon across the intervening broken and barren tableland. They are full of rapids and reefs.

The **Trombetas** is the first river of importance we meet on the northern side as we ascend the Amazon. Its confluence with this is just above the town of Obidos. It has its sources in the Guiana highlands, but its long course is frequently interrupted by violent currents, rocky barriers, and rapids. The inferior zone of the river, as far up as the first fall, the Porteira, has but little broken water and is low and swampy; but above the long series of cataracts and rapids the character and aspect of the valley completely change, and the climate is much better. The river is navigable for 135 miles above its mouth.

The **Negro**, the great northern tributary of the Amazon, has its sources along the watershed between the Orinoco and the Amazon basins, and also connects with the Orinoco at one point. Its main affluent is the Uaupes, which disputes with the headwaters of the Guaviari branch of the Orinoco the drainage of the eastern slope of the "oriental" Andes of Colombia. The Negro is navigable for 450 miles above its mouth for 4 feet of water in the dry season, but it has many sandbanks and minor difficulties. In the wet season, it overflows the country far and wide, sometimes to a breadth of 20 miles, for long distances, and for 400 miles up, as far as Santa Isabella, is a succession of lagoons, full of long islands and intricate channels, and the slope of the country is so gentle that the river has almost no current. But just before reaching the Uaupes there is a long series of reefs, over which the river violently flows in cataracts, rapids, and whirlpools. The Uaupes is full of similar obstacles, some fifty rapids barring its navigation, although a long stretch of its upper course is said to be free from them, and to flow gently through a forested country. Despite the impediments, canoes ascend this stream to the Andes.

---

[1] One of the most daring deeds of exploration ever known in South America was done by the engineer A. Wertheman. He fitted out three rafts, in August 1870, and descended this whole series of rapids and cascades from the Rio Chinchipe to Borja.

The *Branco* is the principal affluent of the Negro from the north; it is enriched by many streams from the sierras which separate Venezuela and British Guiana from Brazil. Its two upper main tributaries are the Uraricuera and the Taqutú. The latter almost links its sources with those of the Essequibo. The Branco flows nearly south, and finds its way into the Negro through several channels and a chain of lagoons similar to those of the latter river. It is 350 miles long, up to its Uraricuera confluence. It has numerous islands, and, 235 miles above its mouth, it is broken by a bad series of rapids.

The **Yapurá**. West of the Negro the Amazon receives three more imposing streams from the north-west—the Yapurá, the Iça or Putumayo, and the Napo. The first was formerly known as the Hyapora, but its Brazilian part is now called the Yapurá, and its Colombian portion the Caquetá. Barão de Marajo gives it 600 miles of navigable stretches; but Crevaux, who descended it, describes it as a frightful river—forests, jungles, rapids, cataracts, torrential rains, cannibals, and fevers throughout its course. It rises in the Colombian Andes, nearly in touch with the sources of the Magdalena, and augments its volume from many branches as it courses through Colombia. It was long supposed to have eight mouths; but Ribeiro de Sampaio, in his voyage of 1774, determined that there was but one real mouth, and that the supposed others are all *furos* or caños. In 1864-68, the Brazilian Government made a somewhat careful examination of the Brazilian part of the river, as far up as the rapid of Cupaty. Several very easy and almost complete water-routes exist between the Yapurá and Negro across the low, flat intervening country. Barão de Marajo says there are six of them, and one which connects the upper Yapurá with the Uaupes branch of the Negro; thus the Indian tribes of the respective valleys have facile contact with each other.

The **Iça**, or **Putumayo**, west of and parallel to the Yapurá, was found more agreeable to navigate by Crevaux. He ascended it in a steamer drawing 6 feet of water, and running day and night. He reached Cuemby, 800 miles above its mouth, without finding a single rapid. Cuemby is only 200 miles from the Pacific Ocean, in a straight line, passing through the town of Pasto in southern Colombia. There was not a stone to be seen up to the base of the Andes; the river banks were of argillaceous earth and the bottom of fine sand.

The **Napo** rises on the flanks of the volcanoes of Antisana, Sincholagua, and Cotopaxi. Before it reaches the plains, it receives a great number of small streams from impenetrable, saturated, and much broken mountainous districts, where the dense and varied vegetation seems to fight for every square foot of ground. From the north, it is joined by the river Coca, having its sources in the gorges of Cayambé on the equator, and also a powerful river, the Aguarico, having its headwaters between Cayambé and the Colombian frontier. From the west, it receives a secondary tributary, the Curaray, from the Andean slopes, between Cotopaxi and the volcano of Tunguragua. From its Coca branch to the mouth of the Curaray, the Napo is full of snags and shelving sandbanks, and throws out numerous caños among jungle-tangled islands, which in the wet season are flooded, giving the river an immense width. From the Coca to the Amazon, it runs through a forested plain where not a hill is visible from the river—its uniformly level banks being only interrupted by swamps and lagoons. From the Amazon, the Napo is navigable for river craft up to its Curary branch, a distance of about 216 miles, and perhaps a few miles farther; thence, by painful canoe navigation, its upper waters may be ascended as far as Santa Rosa, the usual point of embarkation for any venturesome traveller who descends from the Quito tableland. The Coca river may be penetrated as far up as its middle course, where it is jammed between two mountain walls, in a deep cañon, along which it dashes over high falls and numerous reefs. This is the stream made famous by the expedition of Gonzalo Pizarro.

The **Nanay** is the next Amazon tributary of importance west of the Napo. It belongs entirely to the lowlands, and is very crooked, has a slow current, and divides much into caños and strings of lagoons which flood the flat, low areas of country on either side. It is simply the drainage ditch of districts which are extensively overflowed in the rainy season. Captain Butt ascended it 195 miles, to near its source.

The **Tigre** is the next west of the Nanay, and is navigable for 125 miles from its confluence with the Amazon. Like the Nanay, it belongs wholly to the plains. Its mouth is 42 miles west of the junction of the Ucayali with the Amazon. Continuing west from the Tigre we have the Parinari, Chambira, and Nucuray, all short lowland streams, resembling the Nanay in character.

The **Pastaza** is the next large river we meet. It rises on the Ecuadorian tableland, where a branch from the valley of Riobamba unites with one from the Latacunga basin and breaks through the inland range of the Andes; and joined, afterwards, by several important tributaries, finds its way south-east among the gorges; thence it turns southward into the plains, and enters the Amazon at a point about 60 miles west of the mouth of the Huallaga. So far as known, it is a stream of no value except for canoe navigation. Its rise and fall are rapid and uncertain, and it is shallow and full of sandbanks and snags.

The **Morona** flows parallel to the Pastaza and immediately to the west of it, and is the last stream of any importance on the northern side of the Amazon before reaching the Pongo de Manseriche. It is formed from a multitude of water-courses which descend the slopes of the Ecuadorian Andes south of the gigantic volcano of Sangai; but it soon reaches the plain, which commences where it receives its Cusulima branch. The Morona is navigable for small craft for about 300 miles above its mouth, but it is extremely tortuous. Canoes may ascend many of its branches, especially the Cusulima and the Miazal, the latter almost to the base of Sangai. The Morona has been the scene of many rude explorations, with the hope of finding it serviceable as a commercial route between the inter-Andean tableland of Ecuador and the Amazon river. A river called the Paute dashes through the Eastern Andes from the valley of Cuenca; and a second, the Zamora, has broken through the same range from the basin of Loja. Swollen by their many affluents, they reach the lowlands and unite their waters to form the Santiago, which flows into the Marañon at the head of the Pongo de Manseriche. There is but little known of a trustworthy character regarding this river, but Wolf says that it is probably navigable up to the junction of the Paute with the Zamora.

The Main River.

Physical characteristics.

The AMAZON MAIN RIVER is navigable for ocean steamers as far as Iquitos, 2300 miles from the sea, and 486 miles higher up for vessels drawing 14 feet of water, as far as Achual Point. Beyond that, according to Tucker, confirmed by Wertheman, it is unsafe; but small steamers frequently ascend to the Pongo de Manseriche, just above Achual Point. The average current of the Amazon is about 3 miles an hour; but, especially in flood, it dashes through some of its contracted channels at the rate of 5 miles. The U.S. steamer *Wilmington* ascended it to Iquitos in 1899. Commander Todd reports that the average depth of the river in the height of the rainy season is 120 feet. It commences to rise in November, and increases in volume until June, and then falls until the end of October. The rise of the Negro branch is not synchronous; for the steady rains do not commence in its valley until February or March. By June it is full, and then it begins to fall with the Amazon. According to Bates, the Madeira "rises and sinks" two months earlier than the Amazon. The Amazon at times broadens to 4 and 6 miles. Occasionally, for long distances, it divides into two main streams with inland, lateral channels, all connected by a complicated system of natural canals, cutting the low, flat *igapo* lands, which are never more than 15 feet above low river, into almost numberless islands. At the narrows of Ohidos, 400 miles from the sea, it is compressed into a single bed a mile wide and over 200 feet deep, through which the water rushes at the rate of 4 to 5 miles an hour. In the rainy season it inundates the country throughout its course to the extent of several hundred thousand square miles, covering the flood-plain, called *vargem*. The flood-levels are in places from 40 to 50 feet high above low river. Taking four, roughly equidistant places, the rise at Iquitos is 20 feet, at Teffe 45, near Obidos 35, and at Pará 12 feet.

The first high land met in ascending the river is on the north bank, opposite the mouth of the Xingú, and extends for about 150 miles up, as far as Monte Alegre. It is a series of steep, table-topped hills, cut down to a kind of terrace which lies between them and the river. Monte Alegre reaches an altitude of several hundred feet. On the south side, above the Xingú, a line of low bluffs extends, in a series of gentle curves with hardly any breaks nearly to Santarem, but a considerable distance inland, bordering the flood plain, which is many miles wide. Then they bend to the south-west, and, abutting upon the lower Tapajos, merge into the bluffs which form the terrace margin of that river valley. The next high land on the north side is Ohidos, a bluff, 56 feet above the river, backed by low hills. From Serpa, nearly opposite the river Madeira, to near the mouth of the Rio Negro, the banks are low, until approaching Manãos, they are rolling hills; but from the Negro, for 600 miles, as far up as the village of Canaria, at the great bend of the Amazon, only very low land is found, resembling that at the mouth of the river. Vast areas of it are submerged at high water, above which only the upper part of the trees of the sombre forests appear. At Canaria, the high land commences and continues as far as Tabatinga, and thence up stream.

On the south side, from the Tapajos to the river Madeira, the banks are usually low, although two or three hills break the general monotony. From the latter river, however, to the Ucayali, a distance of nearly 1500 miles, the forested banks are just out of water, and are inundated long before the river attains its maximum flood-line. Thence to the Huallaga the elevation of the land is somewhat greater; but not until this river is passed, and the Pongo de Manseriche approached, does the swelling ground of the Andean foot-hills raise the country above flood-level.

The Amazon is not a continuous incline, but probably consists of long, level stretches connected by short inclined planes of extremely little fall, sufficient, however, owing to its great depth, to give the gigantic volume of water a continuous impulse towards the ocean. The lower Amazon presents every evidence of having once been an ocean bay, the upper waters of which washed the cliffs near Ohidos. Only about 10 per cent. of the water discharged by the mighty stream enters it below Ohidos, very little of which is from the northern slope of the valley. The drainage area of the Amazon basin above Obidos is about 1,945,000 square miles, and, below, only about 423,000 square miles, or say 20 per cent., exclusive of the 354,000 square miles of the Tocantins basin.

The width of the mouth of the monarch river is usually measured from Cabo do Norte to Punto Patijoca, a distance of 207 statute miles; but this includes the ocean outlet, 40 miles wide, of the Pará river, which should be deducted, as this stream is only the lower reach of the Tocantins.

Following the coast, a little to the north of Cabo do Norte, and for 100 miles along its Guiana margin up the Amazon, is a belt of half-submerged islands and shallow sandbanks. Here the tidal phenomenon called the *bore*, or Pororoca, occurs, where the soundings are not over 4 fathoms. It commences with a roar, constantly increasing, and advances at the rate of from 10 to 15 miles an hour, with a breaking wall of water from 5 to 12 feet high. Under such conditions of warfare between the ocean and the river, it is not surprising that the former is rapidly eating away the coast and that the vast volume of silt carried by the Amazon finds it impossible to build up a delta.

The Amazon is not so much a river as it is a gigantic reservoir, extending from the sea to the base of the Andes, and, in the wet season, varying in width from 5 to 400 miles. Special attention has already been called to the fourteen great streams which discharge into this reservoir, but it receives a multitude of secondary rivers, which in any other part of the world would also be termed great.

Population, trade, &c.

For 350 years after the discovery of the Amazon, by Pinzon, in 1500, the Portuguese portion of its basin remained almost an undisturbed wilderness, occupied by Indian tribes whom the food quest had split into countless fragments. It is doubtful if its indigenous inhabitants ever exceeded one to every 5 square miles of territory, this being the maximum it could support under the existing conditions of the period in question, and taking into account Indian methods of life. A few settlements on the banks of the main river and some of its tributaries, either for trade with the Indians or for evangelizing purposes, had been founded by the Portuguese pioneers of European civilization. The total population of the Brazilian portion of the Amazon basin in 1850 was perhaps 300,000, of whom about two-thirds were white and slaves, the latter numbering about 25,000. The principal commercial city, Pará, had from 10,000 to 12,000 inhabitants, including slaves. The town of Manãos, at the mouth of the Rio Negro, had from 1000 to 1500 population; but all the remaining villages, as far up as Tabatinga, on the Brazilian frontier of Peru, were wretched little groups of houses which appeared to have timidly effected a lodgment on the river bank, as if they feared to challenge the mysteries of the sombre and gigantic forests behind them. The value of the export and import trade of the whole valley in 1850 was but £500,000.

On the 6th September 1850, the great emperor, Dom Pedro II., sanctioned a law authorizing steam navigation on the Amazon, and confided to an illustrious Brazilian, Barão Mauá (Irineu Evangilista de Sousa), the task of carrying it into effect. He organized the "Companía de Navigação e Commercio do Amazonas" at Rio de Janeiro in 1852; and in the following year it commenced operations with three small steamers, the *Monarch*, the *Marajo*, and *Rio Negro*. At first, the navigation was principally confined to the main river; and even in 1857 a modification of the Government contract only obliged the company to a monthly service between Pará and Manãos, with steamers of 200 tons cargo capacity, a second line to make six round voyages a year between Manãos and Tabatinga, and a third, two trips a month between Pará and Cametá. The Government paid the company a subvention of £3935 monthly. Thus the first impulse of modern progress was given to the dormant valley. The success of the venture called attention to the unoccupied field; a second company soon opened commerce on the Madeira, Purús, and Negro; a third established a line between Pará and Manãos; and a fourth found it profitable to navigate some of the smaller streams; while, in the interval, the Amazonas Company had largely increased its fine fleet. Meanwhile private individuals were building and running small steam craft of their own, not only upon the main river but upon many of its affluents. The Government of Brazil, constantly pressed by the maritime powers and by the countries encircling the upper Amazon basin, decreed, on the 31st July 1867, the opening of the Amazon to all flags; but limited this to certain defined points—Tabatinga, on the Amazon; Cametá, on the Tocantins; Santarem, on the Tapajos; Borba, on the Madeira; Manãos, on the Rio Negro; the decree to take effect on 7th September of the same year. Pará is now a city of over 100,000 inhabitants, Manãos has about 40,000, and the Peruvian town of Iquitos, 10,000. In 1898 there entered the port of Pará 503 ocean steamers and 123 sailing ships—a total of 610,597 tons; and in 1899 the entries of English ocean-going ships reached 314,646 tons register. The first direct foreign trade with Manãos was commenced about 1874. There is now a regular service of two English, one Italian, and one Portuguese line—a total of 35 steamships, representing 52,953 tons register. There is also a Brazilian line of seven ships, of 1999 tons each, running between Manãos and Rio de Janeiro.

The local trade of the river is carried on by the English successors to the Amazonas Company—the Amazon Steam Navigation Company—with 29 steamers, aggregating 9184 registered tons. In addition to its excellent fleet, there are 150 small river steamers belonging to companies and firms in the rubber trade, and 12 of from 150 to 300 tons each, navigating the Negro, Madeira, and Purús rivers. The principal exports of the valley are india-rubber, cacao, Brazil nuts, and a few other products of very minor importance. The india-rubber yield is now from 25,000 to 26,000 tons yearly. The finest quality comes from the Acre and Beni districts of Bolivia, especially from the valley of the Acre (or Aquiry) branch of the river Purús. The yield of these for 1898 was 3151 tons, of which 2000 tons was the official estimate of the product of the Acre district; for 1899, it was 1150 tons; and for the first eleven months of 1900 it was only 791 tons, the decrease being due to the recent unsuccessful attempt of the rubber collectors to segregate the region of the Acre from Bolivia and form a separate republic. Of the rubber production of the Amazon basin, the State of Pará gives about 40 per cent. The cocoa tree is not cultivated, but grows wild in great abundance. The quantity exported for 1899 was 4054 tons. There is but one railway in the whole valley. It runs from Pará towards the coast and is 65 miles long. The cities of Pará and Manãos have excellent tramways, many fine public buildings and private residences, gardens and public squares, all of which give evidence of artistic taste and great prosperity. The import dues collected at the port of Pará in 1899 by the national Government amounted to £844,000. The revenues of the State of Amazonas for the same year were nearly £750,000, of which £476,000 were derived from export duties.

The number of inhabitants in the Brazilian Amazon basin (the States of Amazonas and Pará) is purely a matter of rough estimate. There may be 500,000 or 600,000, or more; for the immigration, during recent years, from the other parts of Brazil has been large, due to the rubber excitement. The influx from the State of Ceará alone, from 1892 to 1899 inclusive, reached 98,348.

As Commander Todd, in his report to the United States Government, says: "The crying need of the Amazon valley is food for the people. . . . At the small towns along the river it is nearly impossible to obtain beef, vegetables, or fruit of any sort, and the inhabitants depend largely upon river fish, mandioc, and canned goods for their subsistence. . . . The ship's company lived, the greater part of the time, upon the regular sea ration, and any ship ascending the Amazon should be well supplied with its own provisions, as it is impossible to live upon the country." Although 400 years have passed since the discovery of the Amazon river, there are probably not 20 square miles of its basin under cultivation, excluding the limited and rudely cultivated areas among the mountains at its extreme headwaters, which are inaccessible to commerce. The extensive exports of the mighty valley are entirely derived from the products of the forest. (G. E. C.)

Amazonas, the largest state of Brazil, in the extreme west of the Republic, has an area of 732,250 square miles. The population in 1872 was 56,610, and in 1890 147,915, of whom nearly two-thirds were Indians. The capital, Manãos, at the mouth of the Rio Negro, has a population of 30,000. The chief towns are Teffe, Itacoatiara (or Serpa), Parintins, Codajaz, and San Gabriel. (See also under AMAZON.)

Amazonas, an interior department of northern Peru, with an area of 13,943 square miles and a population officially estimated at 70,676 in 1896. It is subdivided into three provinces, Bongara, Luya, and Chachapoyas; the principal town, Chachapoyas, has a population of 6000.

Ambala. See UMBALLA.

Amba Mariam. See ABYSSINIA.

Amberg, a town of Bavaria, Germany, district Upper Palatinate, 42 miles E. from Nuremberg by rail. The manufacture of stoneware, zinc goods, and colours is carried on. A former Jesuit monastery is now used for a grammar school and seminary. There are a pilgrimage church, on a hill 1621 ft. high, a large convict prison for men, an industrial and commercial school, &c. Population, 15,812 (1885); 20,200 (1895); 22,039 (1900).

Ambleside, a market-town in the Appleby parliamentary division of Westmoreland, England, a mile from the north end of Windermere. Recent erections are a preparatory school for the novitiate of St Norbert's Home and assembly rooms. Bobbins are manufactured, and in the neighbourhood are slate quarries. Area of parish (an urban district), 4421 acres. Population in 1881, 1989; in 1891, 2360; in 1901, 2536.

Amboyna, a Dutch colony and residency in the east of the East Indian archipelago, which shares with the residency of Ternate the administration of the Moluccas, the previous Government of which was abolished in 1867. The residency includes a mass of islands in the Banda Sea (2° 30′–8° 20′ S. and 125° 45′–135° E.) and is now divided for administrative purposes into nine districts (*afdeelingen*): 1, Amboyna, the island of that name; 2, Saparua, with Oma and Nusa Laut; 3, Kajeli (Eastern Buru); 4, Masareti (Western Buru); 5, Kairatu (Western Ceram); 6, Wahai (the northern part of Mid-Ceram); 7, Amahai (the southern part of Mid-Ceram); 8, The Banda Isles, with East Ceram, Ceram Laut, and Goram; 9, The islands of Aru, Ké, Timor Laut or Tinimber, and the south-western islands. Since 1874 several residents (Riedel, van Hoëvell, &c., see below) have contributed to the geography and ethnography of various groups. The population of the residency (area, about 19,840 square miles) was estimated in 1898 at 295,768 (natives 291,763, Europeans 2346, Chinese 913, Arabs 722, other foreigners 24). The products and means of subsistence in the different groups of islands vary, the culture of cloves being mainly confined to Banda and Amboyna; shipbuilding and the timber trade to the Ké islands; the extraction of cajuput oil to Buru. The shipping, fisheries, and trade are unimportant and generally declining.

See van Hoëvell, *Ambon en de Eliaser* (Dordrecht, 1875).—Riedel, *De sluik-en kroesharige rassen tusschen Selebes en Papua* (den Haag, 1886).—Martin, *Reisen in den Molukken* (Leiden, 1894).

Amboyna (Dutch *Ambon*), the chief island and town of the above residency. The former, lying between 3° 28′–3° 48′ S. and 127° 58′–128° 26′ E., is the last of a series of volcanic isles which form an inner circle in the archipelago round the Banda Sea (Martin). The highest mountains, Wawani (3609 feet) and Salhutu (4020 feet), have hot springs and solfataras. They are considered to be volcanoes, and the mountains of the neighbouring Uliasser islands the remains of volcanoes. Granite and serpentine rocks predominate; but the shores of Amboyna bay are of chalk, and contain stalactite caves (the chief, Batu Lobang). The surface is fertile, the rivers are small and not navigable, and the roads are mere footpaths. Cocoa is one of the products. The population (estimated at 30,000) is divided into two classes—*orang borger* or citizens, and *orang negri* or villagers, the former being a class of native origin enjoying certain privileges conferred on their ancestors by the old Dutch East India Company. The chief town and seat of the resident and military commander of the Moluccas is protected by Fort Victoria, a clean little town with wide streets and numerous schools and churches. Agriculture, fisheries, and trade furnish the chief means of subsistence. The combined value of the exports and imports of late years has been about £85,000 (£83,333 literal conversion). The population is about 8000 (788 Europeans, 696 Chinese, 351 Arabs, 6218 natives).

Ambriz. See Angola.

Ambrosiaster.—A commentary on St Paul's Epistles, "brief in words but weighty in matter," and valuable for the criticism of the Latin text of the New Testament, was formerly but erroneously attributed to St Ambrose; and its author is usually spoken of as Ambrosiaster or pseudo-Ambrose. In modern days it has been ascribed to almost every known Hilary (owing to the fact that St Augustine cites it as by "Sanctus Hilarius"), and to many other writers; above all to Hilary the Roman deacon and (by Langen) to the presbyter Faustinus. Dom Morin has lately argued, with very great plausibility, that the author was one Isaac the Jew, who became a Christian and joined the party of the anti-pope Ursinus, and was instigated by them to make criminal charges against Pope Damasus. These were ultimately dismissed, and Isaac was exiled to Spain 378-380. In 380 he relapsed to Judaism; and nothing appears to be known of his later life.

Dom Morin first shows that none of the earlier attempts to identify Ambrosiaster can be accepted as satisfactory; that the *Quaestiones Veteris et Novi Testamenti* formerly ascribed to Augustine are also his (the attempt of C. Marold to disprove this breaking down entirely); that he wrote between 374 and 384 A.D., and that he lived and wrote at Rome. Then he compares the *Quaestiones* and *Commentaria* with the little tract of Isaac the Jew on the Trinity and Incarnation, and with an incomplete *Expositio Fidei* printed by Caspari (*Kirchenhist. Anecdota*, 304 f). which, if not part of the same work, is nearly allied to it; and the comparison shows how close their literary and theological affinities are. Next, Ambrosiaster's writings are shown to contain just such characteristics as might be expected from Isaac the Jew: a captious spirit of reform, exact knowledge of Judaism, and a legalist temperament; whilst there is no insuperable objection to such authorship. And lastly, the later history of Isaac would account for the subsequent uncertainty as to the authorship of the writings.

See G. Morin. "L'Ambrosiaster et le juif converti Isaac" in *Revue d'histoire et de littérature religieuses*, tom. iv. 97 f. Paris, 1899. —Arnold. Art. "Ambrosiaster" in Herzog-Hauck, *Real-Encyklopädie für protestantische Theologie*, i. 441. Leipzig, 1896.—J. Langen. *Geschichte der römischen Kirche*, i. 600 f. Bonn, 1881.

(W. E. Co.)

Ambulance.—Medical organization for military field service comprises all the arrangements for the care and treatment of the sick and wounded from the time they are injured or taken ill till they are able to return to duty or are invalided home. In the British service, not only land transport but hospital ships are required. The working of the system is as follows (the case of a soldier wounded in action in South Africa being taken as an example). When he falls he is attended by the regimental surgeon and stretcher-bearers, who apply some extemporized method of stopping bleeding and dress the wound with the dressing—a packet of antiseptic appliances—which every fighting man carries stitched into the inside of his tunic, and which contains all things necessary for dressing and bandaging an ordinary gunshot wound. From the field he is carried on a stretcher by the men of the bearer company of the Royal Army Medical Corps to the collecting station, where he is placed in an ambulance waggon of the first line of assistance and taken to the dressing station. Here his wound will be examined, any operation urgently required will be performed, and a specification tally stating the nature of the injury and any other important facts connected with the case will be attached to him (if this has not already been done by the regimental surgeon), in order to avoid the disturbance and pain of repeated examinations. After this, and perhaps the administration of nourishments, stimulants, or opiates, the patient is moved to the field hospital in an ambulance waggon of the second line of assistance. From the field hospital he is transferred as soon as possible by the ambulance train to a general hospital at the advanced base of operations, and from there in due time in another train to the base of operations at the coast, from which he is ultimately either returned to duty or sent home in a hospital ship.

The organization by which these requirements are fulfilled is the following:—Every regiment and fighting unit has posted to it, on proceeding on active service, a medical officer who looks after the health of the men and advises the commanding officer on sanitary matters. When the regiment goes into action he takes command of the regimental stretcher-bearers to the number of two per company who have previously been instructed in first aid and in the carrying of the wounded on stretchers. These men leave their arms behind and wear the Red Cross armlets so as to be under the protection of the Geneva Convention, but when a battle takes the form of magazine rifle fire, continued for many hours without either side advancing or retiring much, it may not be the fault of the enemy that the bearers and medical officers are sometimes shot in attending to the wounded.

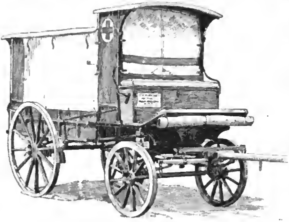


Fig. 1.—Type of British Army Ambulance.

The bearer company, into whose charge the wounded man next passes, is composed of three officers, thirteen non-commissioned officers, and forty-eight privates of the Royal Army Medical Corps, with a detachment of the Army Service Corps for transport duties. There is one such bearer company to every brigade, and six to an army corps, and their duties are to collect and succour the wounded on the battlefield, handing them over to the field hospitals, with which the companies are closely associated, though separately organized. In the Indian army the bearer company is provided *pro tem.* from the personnel of the field hospital when there is a battle, and then reverts to the hospital again after it is over. The teaching of the South African war rather points to the advantage of the Indian plan, for after action the bearer company personnel should be available to give the much-needed help in the work of the field hospital. The bearers afford the wounded any treatment necessary, supply water and sedatives, and then carry them back on stretchers to the collecting station in the rear, whence they are conveyed to the dressing station in waggons or other form of transport (mule cacolets or litters in mountainous districts where wheeled carriages cannot go, camel cacolets and litters in the Sudan, dhoolies or Lushai dandies in India, hammocks on the West Coast of Africa, or sedan chairs in China). Cacolets are seats slung on each side of a pack saddle. British ambulance waggons (Figs. 1, 3), which are built very strongly to stand rough roads, are of several patterns. They have been reported upon as heavy and uncomfortable in the South African war, and they can only carry two men so seriously wounded as to have to lie down, besides those seated; but a new vehicle has been tried which will convey four cases lying down as well as six seated, or fourteen all seated. All patterns of waggons weigh from 17½ to 18½ cwt. At the dressing station—which ought to be out of range of the firing, and near a good water supply—the patient is made as comfortable as possible; nourishment and stimulants are administered, and he is then taken to the field hospital. There is one field hospital to each brigade, but since in larger organizations extra accommodation is required for the corps troops not included in brigades, such as the ammunition supply columns, balloon and bridging detachments, &c., the total number of field hospitals for an army corps (roughly speaking 40,000 men) is ten. In times of great stress when it is desirable to remove the wounded quickly from the field, and there are no roads, or wheeled transport is not obtainable, it is becoming the custom to employ bearers in large numbers, temporarily engaged, whom a little training will render fairly efficient for the purpose. This was done in Natal at the battle of Spion Kop, and also in the Egyptian campaigns, where the local troops not required for the fighting line were requisitioned, and the arrangement was in both instances considered successful.

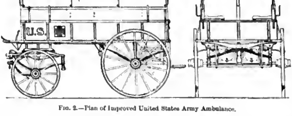


Fig. 2.—Plan of Improved United States Army Ambulance.

Ambulance Organization of the Indian Army.

In India the rank and file of the Royal Army Medical Corps are not employed, the bearer work being carried out by natives called kahars, specially enlisted. These men are bearers by caste, and are most expert in carrying the dhoolies and dandies which are used instead of stretchers—except those used by the regimental (European) stretcher-bearers—and their courage on the battlefield is the admiration of all beholders. The same remark applies to the bheesties or water-carriers, who also accompany the troops into action. The ambulance organization of the army in India thus differs materially from that elsewhere. The main difference is that, as already stated, the rank and file of the Royal Army Medical Corps are not employed, although the commissioned officers are. The warrant and non-commissioned ranks are replaced by a most useful body of men of Anglo-Indian or Eurasian birth called the Subordinate Medical Department, the members of which, now called assistant surgeons, formerly apothecaries, receive a three years' training in medical work at the Indian universities, and are competent to perform the compounding of medicines and to undertake the management of all but the most serious cases of illness and injury. The privates of the Royal Army Medical

Corps are replaced by natives graded as ward servants, cooks, water-carriers, and sweepers. The caste system necessitates this division of labour, and the men are not so efficient or so trustworthy as the regular soldiers whose places they take. The bearers of the sick and wounded are a separate and distinct class, as above explained, and they are in part attached to regiments as a portion of the regimental transport, and in part to the field hospital bearer companies on mobilization. The dandies, a more portable form of the old-fashioned dhoolie, are very comfortable, and have a canvas roof and curtains to keep off sun and rain. They are borne slung on a long bamboo upon the shoulders of four or more men, but being very heavy and clumsy are not well suited for mountain warfare; moreover, as they cannot be folded up into a smaller compass for transport like a stretcher, they take up a great deal of room in railway trucks, and cannot be carried on the backs of animals. Hence riding ponies and mules are much used in Indian warfare for transporting the less severely wounded men. The ambulance tongas of India are small, very strongly built two-wheeled bullock or mule carriages capable of carrying four men seated or two lying down; but the most serious cases are carried in dandies all the way from the field to the hospital. In India it is necessary to provide separate hospitals for the white and black troops, and also to have accommodation in the latter case for the large numbers of non-combatant camp-followers who are employees of the commissariat department, servants, grooms, cooks, bullock- and mule-drivers, and the like. The frontier war of 1897-98 may be taken to illustrate the medical organization of the Indian army. In that war 18,688 white troops, 41,677 native troops, and 32,696 followers were engaged, and for the accommodation of these there were fourteen field hospitals for white troops and twenty-two for native troops, each having 100 beds. Attached to the corps engaged were 150 dandies, 274 stretchers, and 900 bearers, while the field hospitals and bearer companies had a personnel of 9658, with 720 dandies and 720 tongas.

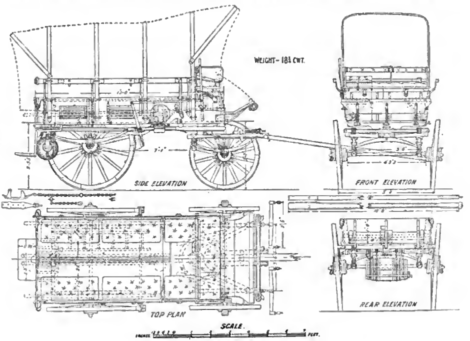


FIG. 3.—Plan of British Army Ambulance.

Field hospitals are each supposed to provide accommodation for 100 patients, who live upon their own field rations **Hospitals.** suitably cooked and supplemented by medical comforts. The patients are not supplied with hospital clothing, nor do they have beds, but lie on straw spread on the ground and covered with waterproof sheets and blankets. Thus field hospitals can and must at times accommodate more than the proper number of patients, but in the South African war their resources were at times considerably overtaxed, with consequent discomfort and hardship. These hospitals are supposed to move with the army, and therefore it is imperative to pass the wounded quickly back from them to the hospitals on the lines of communication (which vary in number according to the length of that line), and thence to the general hospital at the base. The size of these hospitals on the lines of communication varies according to circumstances; they are as a rule dieted—that is to say, proper hospital diets and not field rations are issued to the patients, who also have beds and proper hospital clothing. In these hospitals there may be nursing sisters, who are unsuited for the rough life and work nearer the front. Sisters may also be employed on the hospital trains, which were found very useful in the South African war, being fitted with beds, kitchens, dispensaries, &c., so that the patients were removed long distances in comfort. Having arrived at the base of operations the wounded are transferred to the general hospitals. The numbers and situation of these vary with circumstances and requirements, but according to regulations there is supposed to be one of 520 beds to each field force of 20,000 men. Each is fully equipped with beds, clothing, diets, &c., and the staff consists of 21 officers, 9 nursing sisters, 3 warrant officers, 25 non-commissioned officers, and about 120 privates. There are separate officers' wards. In South Africa, owing to the impossibility of the Royal Army Medical Corps meeting all the requirements of the enormous force engaged, many of the officers attached were civil doctors, and the rank and file were often civilians drawn from the St John's Ambulance Brigade and men temporarily enlisted from the Volunteer Medical Staff Corps. Many of the nursing sisters belonged to the Army Nursing Reserve, who are ordinarily employed in the civil hospitals, but liable to be drafted to the seat of war.

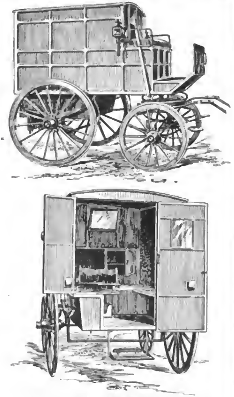


Fig. 4.—Type of English Civil Ambulance (side and rear view).

In the South African war the patriotism and liberality of the British public furnished several general hospitals, perfectly equipped and officered by some of the most eminent members of the medical profession in the United Kingdom. Among others may be mentioned the Princess Christian, the Imperial Yeomanry (both field and general), the Langman, the Portland, the Irish, Scottish, and Welsh hospitals. In addition to the staff of these hospitals, several eminent surgeons, including Sir Wm. Mac Cormac and Sir Frederick (then Mr) Treves, went out as consultants. These civil hospitals were staffed entirely by civilians, except that an officer of the R.A.M.C. was attached to each as administrator and organizer; and their personnel was made up of physicians, surgeons, nurses, dressers (who were medical students, and in some cases qualified surgeons), and servants. The numbers of course varied according to the size of the hospitals; in the case of the Portland hospital of 100 beds, for example, the staff comprised 41 individuals of the various grades.

Lastly, our wounded man is transferred to a hospital ship. This is fitted up with comfortable swinging cots in airy wards, refrigerators, punkahs for hot weather, and every other luxury which modern science can supply. Each division of an army corps is supposed to have attached to it, when necessary, a hospital ship of 200 or 250 beds, which is provided with medical officers, nursing sisters, and the same staff and equipment as hospitals ashore.

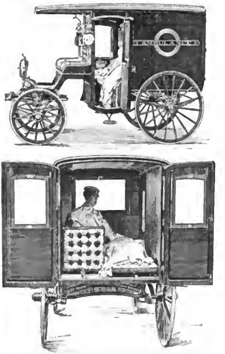


Fig. 5.—Type of American Civil Ambulance (side and rear view).

The medical staff of the regular army in the South African war in its later stage comprised the following officers:—1 surgeon-general, 11 colonels, 41 lieut.-colonels, 183 majors, 71 captains, and 115 lieutenants—total 422 officers. The total strength of the Royal Army Medical Corps at that time was 905, and out of the balance there were 365 officers employed in other foreign stations, and only 118 at home. This shows how severely the war taxed the resources of the corps. Probably there were as many civil, colonial, and volunteer medical officers employed at the front as there were army medical officers. Of the rank and file of the Royal Army Medical Corps there were over 3000 men employed, and about the same number of St. John's ambulance men, and other civilians and volunteers. To the army medical organization in war time is affiliated that of the Red Cross Society and other charitable associations, which during the South African war aided the medical services greatly by the provision of clothing, money, and numerous luxuries for the sick and wounded.

The material and equipment for the bearer companies, field hospitals, &c., are stored in times of peace at the various head-quarters stations in the United Kingdom, and on the orders for mobilization being issued, the personnel told off for each unit repairs to the allotted station, draws the equipment and transport, and embarks with the brigade to which it is attached. The transport of the ambulance department has profited by the concentration in strength of drugs, and the arrangements whereby space is economized. As the fighting man can carry in his wallet nourishment enough for thirty-six hours in the form of an emergency ration in a tin the size of a cigar-case, and enough sweetening material in the form of saccharine to last him a fortnight, in a bottle the size of a watch, so the medical department can take compressed tabloids of drugs, each tabloid being a dose, and each taking up about one-tenth of the space the drug would otherwise occupy; while the medical officers can carry hypodermic cases, not so large as ordinary cigarette-cases, containing a syringe and hundreds of doses of highly concentrated remedies. The traction-engines with the army can supply steam-power for X-ray and electric-light work, ice-making, &c.

Foreign Methods.

The American Civil War (1861-65) marked the commencement of the modern ambulance system. The main feature, however, of the hospital organization throughout that campaign was the railway hospital service, which provided for the rapid conveyance of the sick and wounded to the rear of the contending armies. These hospital carriages (Fig. 2), equipped with medical stores and appliances for the transport of cases from the front to the base, were rapidly introduced into other armies, and played a great part in the ambulance service of the Franco-German war. On the continent of Europe, the two rival military Powers, France and Germany, who were not slow to follow the American lead, have since 1871 still further developed and improved their ambulance systems. The German hospital service for armies in the field was modified and extended by the "Kriege Sanitats ordnung" of 1878 and the "Kriege Etappen ordnung" of 1887, which completed the organization by the addition in time of war of numerous subordinate offices and departments. The peace organization does not materially differ from the English system. The main divisions of the ambulance organization of the German army in the field would now fall into (1) sanitary detachments; (2) field hospitals; (3) flying hospitals; hospital reserve depôts; (5) commissions of transport ambulance; and (6) railway hospital trains. The whole administration of the ambulance service of the grand army in the field is in the hands of the chief of the army sanitary staff, who is attached to headquarters. Next in command come surgeons-general of armies operating in the field, surgeons-general of army corps, and under them again surgeons-in-chief of divisions and regiments. Civil consulting-surgeons of eminence, notably professors from the universities, are also attached to the various armies and divisions to co-operate with and act as advisers to the surgeons of the standing military surgical staff. The hospital transport service on the lines of communication is highly organized, and the hospital railway carriages are equipped on an elaborate scale. The French ambulance system, finally settled by the règlement of 1884, is organized on almost identical lines with the German. But the chief point wherein the German and French ambulance systems differ from the British lies in the military organization of the volunteer assistance offered by the various Red Cross societies under the Geneva flag. Whereas in France and Germany such aid is officially recognized and placed under direct military control, the English Red Cross societies act side by side with, but independently of, the military ambulance organization. In Germany the volunteer organization is presided over by an imperial commissioner or inspector-general, appointed in peace time, who in time of war is attached to the headquarters staff. His functions are to control the relations of the various Red Cross societies, and to secure their harmonious inter-working. Delegates appointed by him are attached to the various corps and transport commissions. No volunteer assistance can be utilized which is not entirely subordinated to the military control, and which has not already in peace time received official recognition, and been organized on a skeleton footing. Moreover, only persons of German nationality can be employed under it with the armies in the field. In the case of base hospitals situate in Germany itself, the services of foreigners may be enlisted by special permission of the war office. In France, in the main, the same rules obtain in the case of the volunteer hospital service.

Civil ambulances.—In 1878 the British ambulance association of St. John of Jerusalem was founded. Its object was to render first aid to persons injured in accidents on the road, railway, or in any of the occupations of civil life. As a result of the initiative taken by this society, ambulance corps have been formed in most large towns of the United Kingdom; and police, railway servants, and workmen have been instructed how to render "first aid" pending the arrival of a doctor (Fig. 4). This Samaritan work has been further developed and extended to most parts of the British Empire, notably to Canada, Australia, and India. In the United States the civil ambulance is not general. Each city has its own system and organization. In some the ambulance service is worked by the police, as in Boston; in others, notably New York, by the hospitals (Figs. 5, 6), whilst Chicago boasts an admirable ambulance service under municipal control. Apart from these "Samaritan" services, as they may be called, there is also in most of the larger cities of America a specially organized police ambulance for the rapid conveyance of arrested persons to the police stations. In most of the capitals of Europe there are likewise civil ambulance organizations dispensing "first aid" in urgent cases, but their *modus operandi* is in no special feature distinguishable from that of the ambulance association of St. John. (J. R. D.)

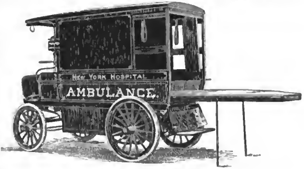


FIG. 6.—Type of Motor Ambulance.

Amedeo Ferdinando Maria di Savoia, DUKE OF AOSTA (1845-1890), third son of Victor Emmanuel II., king of Italy, and of Adelaide, archduchess of Austria, was born at Turin on 30th May 1845. Entering the army as captain in 1859 he fought through the campaign of 1866 with the rank of major-general, leading his brigade into action at Custozza and being wounded at Monte Torre. In May 1867 he married the Princess Maria Carlotta Del Pozzo della Cisterna. In 1868 he was created vice-admiral of the Italian navy, but, two years later, left Italy to ascend the Spanish throne, his reluctance to accept the invitation of the Cortes having been overridden by the Italian Cabinet. On 16th November 1870 he was proclaimed king of Spain by the Cortes; but, before he could arrive at Madrid, Marshal Prim, chief promoter of his candidature, was assassinated. Undeterred by rumours of a plot against his own life, Amedeo entered Madrid alone, riding at some distance from his suite to the church where Marshal Prim's body lay in state. His efforts as constitutional king were paralysed by the rivalry between the various Spanish factions, but with the approval of his father he rejected all idea of a *coup d'état*. Though warned of a plot against his life (18th August 1872) he refused to take precautions, and, while returning from Buen Retiro to Madrid in company with the queen, was repeatedly shot at in Via Avenal. The royal carriage was struck by several revolver and rifle bullets, the horses wounded, but its occupants escaped unhurt. A period of calm followed the outrage. On 11th February 1873, however, Amedeo, abandoned by his partisans and attacked more fiercely than ever by his opponents, signed his abdication. Upon returning to Italy he was cordially welcomed and reinstated in his former position. His consort, whose health had been undermined by anxiety in Spain, died on 3rd November 1876. Not until 11th September 1888 did Amedeo contract his second marriage with his niece, Princess Letitia Bonaparte. Less than two years later (18th January 1890) he died at Turin in the arms of his elder brother, King Humbert I., leaving four children—the duke of Aosta, the count of Turin, the duke of the Abruzzi, and the duke of Salemi. (H. W. C.)

AMERICA.

General formation.

THE historical accident that resulted in the use of a single name, America, for the pair of continents that has a greater extension from north to south than any other continuous land area of the globe, has had some justification in recent years, since geological opinion has begun to turn in favour of the theory of the tetrahedral deformation of the earth's crust as affording explanation of the grouping of continents and oceans. America, broadening in the north as if to span the oceans by reaching to its neighbours on the east and west, tapering between vast oceans far to the south where the nearest land is in the little-known Antarctic regions, roughly presents the triangular outline that is to be expected from tetrahedral warping; and although greatly broken in the middle, and standing with the northern and southern parts out of a meridian line, America is nevertheless the best witness among the continents of to-day to the tetrahedral theory. There seems to be, however, not a unity but a duality in its plan of construction, for the two parts, North and South America, resemble each other not only in outline but, roughly speaking, in geological evolution also; and the resemblances thus discovered are the more remarkable when it is considered how extremely small is the probability that among all the possible combinations of ancient mountain systems, modern mountain systems, and plains, two continents out of five should present so many points of correspondence. Thus regarded, it becomes reasonable to suppose that North and South America have in a broad way been developed under a succession of somewhat similar strains in the earth's crust, and that they are, in so far, favourable witnesses to the theory that there is something individual in the plan of continental growth. The chief points of correspondence between these two great land masses, besides the southward tapering, are as follows:—(1) The areas of ancient fundamental rocks of the north-east (Laurentian highlands of North America, uplands of Guiana in South America), which have remained without significant deformation, although suffering various oscillations of level, since ancient geological times; (2) the highlands of the south-east (Appalachians and Brazilian highlands) with a north-east south-west crystalline axis near the ocean, followed by a belt of deformed and metamorphosed early Palæozoic strata, and adjoined farther inland by a dissected plateau of nearly horizontal later Palæozoic formations—all greatly denuded since the ancient deformation of the mountain axis, and seeming to owe their present altitude to broad uplifts of comparatively modern geological date; (3) the complex of younger mountains along the western side of the continents (Western highlands, or Cordilleras, of North America; Andean Cordilleras of South America) of geologically modern deformation and upheaval, with enclosed basins and abundant volcanic action, but each a system in itself, disconnected and not standing in alignment; (4) confluent lower lands between the highlands, giving river drainage to the north (Mackenzie, Orinoco), east (St Lawrence, Amazon), and south (Mississippi, La Plata). Differences of dimension and detail are numerous, but they do not suffice to mask what seems to be a resemblance in general plan. Indeed, some of the chief contrasts of the two continents arise not so much from geological unlikeness as from their unsymmetrical situation with respect to the equator, whereby the northern one lies mostly in the temperate zone, while the southern one lies mostly in the torrid zone. North America is bathed in frigid waters around its broad northern shores; its mountains bear huge glaciers in the north-west; the outlying area of Greenland in the north-east is shrouded with ice; and in geologically recent times a vast ice-sheet has spread over its north-eastern third; while warm waters bring corals to its southern shores. South America has warm waters and corals on the north-east, and cold waters and glaciers only on its narrowing southern end. If the symmetry that is so noticeable in geological history had extended to climate as well, many geographical features might now present likenesses instead of contrasts.

When America is compared with the continents of the Old World, an important correspondence is found between its northern member and the greater part of Eurasia; but here the corresponding parts are reversed, right and left, like the two hands. The Laurentian highlands agree with Scandinavia and Finland, both having escaped deformation since very ancient times. A series of water bodies (the Great lakes in North America, the southern Baltic, with Onega, Ladoga, &c., in Europe) occupy depressions that are associated with the boundary between the very ancient lands and their less ancient covering strata. The old worn-down and re-elevated Appalachian mountains of south-eastern North America agree well with the Hercynian mountains of similar history in middle Europe (Ardennes, Slate mountains of the middle Rhine, &c.), each range entering the Atlantic at one end (in Nova Scotia and Newfoundland; in Brittany, Wales, and Ireland), and dipping under younger formations at the other. Certain younger ranges—seldom recognized as mountains because they are mostly submerged in the American mediterraneans (Gulf of Mexico and Caribbean Sea), but of great absolute relief and with crests rising in the larger West Indian islands—may be compared with the younger ranges of southern Europe (Pyrenees, Alps, Caucasus) bordering the classic Mediterranean and the seas farther east. The central plains of North America correspond well with the plains of Russia and western Siberia; both stretch from great enclosed water bodies on the south to the Arctic Ocean, and both are built of undisturbed Palæozoic strata toward the axis of symmetry and of younger strata away from it. Finally, the Western highlands of North America may be compared with the great mountain complex of central and eastern Asia. In this remarkable succession of resemblances, we find one of the best proofs of the continental unity of Eurasia, however independently Europe and Asia should have been developed on a tetrahedral earth, and however fully the separation of these two grand divisions is demanded on historical and political grounds. Moreover, the resemblances thus described controvert the idea, prevalent when geology was less advanced than to-day, that the New World of civilised discovery is an "old world" geologically, and that the Old World of history is geologically "new." Both worlds are so old, and both share so well the effects of successive geological changes from the most ancient to the most modern periods, that neither can regard the other as older or younger than itself. No simple generalization is admissible concerning the age of anything whose history is so complicated as that of a continent.

The climatic contrasts between North and South America are replaced by several climatic similarities between North America and Eurasia. The Appalachians and the Hercynian mountains of middle Europe both contain extensive coal deposits of similar geological age, thus indicating a climatic and geographic resemblance at a time of great antiquity. The Laurentian highlands and the Scandinavian highlands were both heavily and repeatedly glaciated in recent geological times, and the ice sheets that crept out on all sides from those centres spread far over the lower lands to the south and away from the axis of symmetry towards the continental interior, scouring the central highlands and leaving them rocky and barren, strewing extensive drift deposits over the peripheral areas, and thus significantly modifying their form and drainage; while the much loftier mountain ranges of western America and central Asia suffered, singularly enough, a far less extensive glaciation. At the present time, the plentiful and well-distributed rainfall of the continental border on either side of the Atlantic is succeeded by an increasing aridity towards the continental interior, until the broad plains that rise towards the distant mountain complexes are comparatively barren or even desert. Within each greater mountain area extensive interior drainage basins are found holding salt lakes, and the suspected former extension of these lakes in central Asia agrees well with the proved extension of the lacustrine conditions in western North America. In matters of temperature, however, there are certain contrasts, as will be more fully stated below when the question of climate is discussed.

NORTH AMERICA.

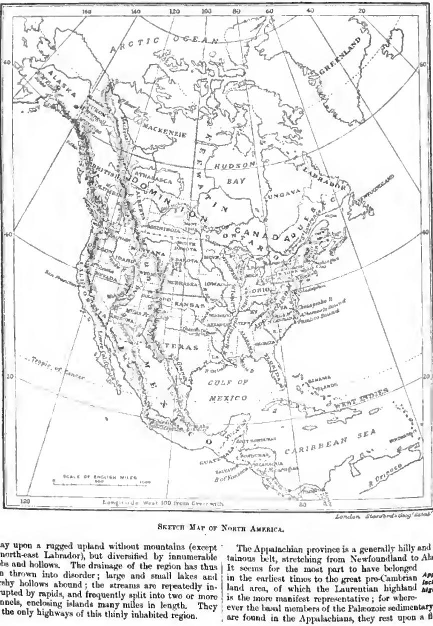
The following sketch of the geological development of North America considers the larger physiographic divisions in the order already presented.

Laurentian highlands.

The extensive area of ancient crystalline rocks (Archæan), stretching from Labrador past Hudson Bay to the Arctic Ocean, is of greatly disordered structure, and hence must have once had a mountainous form. Moreover, the crystalline texture and deformed foliation of the rocks prove that the surface now seen was once buried deep beneath the surface of an earlier time, for only at great depths can such texture and foliation be acquired. Both these lines of evidence lead to the conclusion that the moderate relief prevalent over the existing Laurentian region is the work of persevering erosion during a long continuance of dry land conditions, and hence that the region must be regarded as one of those worn-down mountain systems which so eloquently testify to the vast duration of geological time. But the full value of this testimony is appreciated only when it is discovered that the worn-down old land is gently overlapped, chiefly around the south and west, and south of Hudson Bay, by very early Palæozoic strata which rest upon the eroded surface of the crystallines, thus proving that the destruction of the ancient mountains had already been accomplished before some of the oldest fossiliferous formations of the world had been deposited. All the evidence goes to prove that from then to now the Laurentian region has been relatively quiescent, as if the forces of deformation had been exhausted by their efforts in the earlier ages of the earth's history. In all subsequent time there have been here no such great crushings and upheavals as have occurred elsewhere, but only moderate oscillations of level, one of which allowed the transgression of the ancient sea in which the overlapping strata were deposited, while another of much more modern date gave the region its present highland altitude (1000 to 2000 feet; mountains near the Labrador coast, 8000 feet), again offering it to the forces of erosion.

It is this ancient Laurentian area that the earlier geologists named the "Continental Nucleus," as if it had been the first part of North America to rise from the primeval waters of an assumed universal ocean. The "Archæan V," formed by the two arms of the Laurentian oldland stretching from Labrador to the Arctic, between which Hudson Bay is included, has been repeatedly described as the oldest area of the continent, the beginning around which many later additions have built the existing outlines; and as such it has been adduced in favour of the theory of the permanence of continents. But when thus stated, the half of the story in favour of this theory is not told. Hudson Bay is not due to a primitive failure of elevation between the arms of the "Archæan V"; it is not a deep basin whose floor has never emerged from the primeval ocean, but an ancient and comparatively shallow depression in a pre-existent land, over which the sea flowed as the surface sank below sea-level. South and west from the "Archæan Nucleus," the Cambrian strata of the medial plains of North America are found to lie, wherever their base is discovered, on a foundation that possesses all the essential features of the Laurentian oldland. This relation is found all around the Adirondack mountains in New York, along the Appalachians southward to Georgia, through the Mississippi basin in Wisconsin and Missouri, and beyond in Texas, and farther west in the Black Hills, as well as certain points in the Rocky Mountains region. Hence the pre-Cambrian land surface of the continent must have had not only a vastly greater area than was formerly attributed to it, but also an earlier origin; for at the time when it was thought by the older geologists to be first rising from the primeval ocean, it is now proved to have been slowly sinking after a prolonged land existence. The crystalline Archæan rocks in the Laurentian region and its scattered fellows cannot possibly be explained as a primitive sea bottom, rising above sea-level to make the beginning of a continent and receiving Cambrian strata upon its still submerged borders, but only as portions of an already old and deeply-denuded land area, which was in pre-Cambrian time much larger than the visible Laurentian area of to-day, and which was reduced to perhaps half its primeval dimensions by a gradual submergence beneath the transgressing sea in which the Cambrian sediments were laid down. We are thus led to believe that much of the continent of to-day was a continent in the earliest geological times, and that the seas which partly covered it in Palæozoic and Mesozoic time were due to partial submergence, not to partial emergence. Furthermore, all the marine strata that now stretch over a large part of what is believed to have been the ancient continental surface are of relatively shallow water origin; none of them bear any close resemblance to the deposits of the deep oceans that have been so well studied in the last thirty years. Hence the Palæozoic and Mesozoic seas of North America were not deep oceans, and as far as this continent is concerned it is by no means admissible to assume, as some of the earlier geologists did, that the position of continents and oceans have repeatedly changed places. The testimony of the rocks is decidedly in favour of Dana's view that continental masses are relatively permanent, and hence also, as far as stability is concerned, in favour of the theory of a tetrahedral earth.

The early history of the Laurentian region has been dwelt upon because of its great importance in the history of the continent, and because its history has so generally been misunderstood. To these reasons may be added a third: through Palæozoic and Mesozoic time the history of the Laurentian region is for the most part a blank. Records are wanting from the early Palæozoic to the Pleistocene, when the Laurentian uplands became the centres from which the ice sheets of the Glacial period spread out on all sides. As a result of this late chapter in the history of the region, the weathered soils of earlier periods were swept away along with an unknown amount of firm rock, leaving bare ledges, scattered boulders, and gravelly drift to-day upon a rugged upland without mountains (except in north-east Labrador), but diversified by innumerable knobs and hollows. The drainage of the region has thus been thrown into disorder; large and small lakes and marshy hollows abound; the streams are repeatedly interrupted by rapids, and frequently split into two or more channels, enclosing islands many miles in length. They are the only highways of this thinly inhabited region.



Sketch Map of North America.

Appalachian highlands.

The Appalachian province is a generally hilly and mountainous belt, stretching from Newfoundland to Alabama. It seems for the most part to have belonged in the earliest times to the great pre-Cambrian land area, of which the Laurentian highland is the more manifest representative; for wherever the basal members of the Palæozoic sedimentary series are found in the Appalachians, they rest upon a floor of denuded Archæan rocks, and the lowest layers are largely composed of Archæan detritus. This province must, however, be set aside from the undisturbed Laurentian region because of the repeated movements of depression, deformation, and elevation that it has suffered, generally along a north-east south-west trend, causing the successive alternations of heavy deposition, and almost equally heavy denudation that have prevailed with varying intensity during the whole stretch of geological time covered by the fossiliferous record. The earliest important mountain-making disturbances interrupted the conditions of deposition in Cambrian time, and produced what has been called the Green Mountain system. A later, and probably greater, disturbance, with its climax at the close of Carboniferous time, established the Appalachian Mountain system; but, as understood to-day, the "Appalachian revolution" of the older geologists should be regarded as a long-lasting process, perhaps intermittently enduring as long as the whole of Carboniferous time. A subordinate period of deposition and deformation occurred early in Mesozoic time, marked by the accumulation and disturbance of several basins of the Newark formation, roughly corresponding to the Triassic of Europe.

The Appalachian mountains of to-day were formerly regarded as the unconsumed remnants of the chief Appalachian uplift; but it is now generally agreed that Mesozoic erosion reduced the greater part of the range to a lowland of moderate or small relief, leaving only isolated groups of subdued mountains in the areas of the most resistant rocks, and that the altitude and form of the mountains are chiefly the result of the Tertiary elevation and dissection of the previously worn-down mass,—the additional height thus given in Tertiary time to the pre-existent subdued mountain groups making them now the loftiest areas of the range, as in the White Mountains of New Hampshire (Mount Washington, 6293 feet), and the Black Mountains of North Carolina (Mount Mitchell, 6711 feet). It is interesting to note that the axis of Tertiary elevation is nearly parallel to and closely associated with the axes of the earlier disturbances, but it lies somewhat to the north-west of its predecessors, and therefore involves considerable areas of flat-lying Palæozoic strata on the inner side of the previously disturbed belt from New York to Alabama, thus producing what is known as the Allegheny plateau (altitudes, 2000 to 4000 feet). It should be added that the Ozark plateau of Missouri and the Ouachita mountains on the south in Arkansas and farther west are related to one another in much the same way as the Allegheny plateau and the middle ranges of the Appalachians—the two pairs corresponding to a remarkable degree in regard to conditions of ancient accumulation, mediæval deformation and denudation, and more modern uplift and dissection; it is, therefore, admissible to classify this western group of uplifts as an annex to the normal Appalachians. Numerous and extensive coal seams occur in the worn-down Appalachians of Nova Scotia, Pennsylvania, and Alabama, as well as in the Allegheny plateau from Pennsylvania to Alabama, and in the extension of the same strata through the Ohio and middle Mississippi basins.

The eastern coast of the continent has a ragged shore line from Maine to Greenland, with numerous submerged lowlands and valleys forming bays, and as many uplands and ridges outstretching in promontories and islands; this being the result of the summation of many movements of the land, whose total gives an increasing measure of depression to the north where an archipelago at last replaces what was probably once a corner of the continent; but the measure of the depression is uncertain, because of the doubt regarding the depth beneath sea-level to which the Pleistocene glaciers may have worn the pre-Glacial valleys. South of New England, along the Atlantic coast, and around the border of the gulf into Mexico, the dominating movement of the land in late geological periods has been upward with respect to sea-level, whereby a former sea bottom, on which the land waste of Cretaceous and Tertiary times had been outspread, was revealed as a coastal plain, across which the rivers of the former land area now extend their courses, from the old shore line to the new. Part of the same plain, still submerged, forms the "continental shelf" of the mid-Atlantic border. Florida seems to be a projecting swell of this shelf, around whose extremity coral reefs have been added, but whose greater mass is still under a shallow sea cover. Along the ragged coast in the north a moderate and very modern movement of elevation has laid bare clay-floored lowlands that were lately beneath the sea, as in the plain of the lower St Lawrence valley, while along the coastal plain of the south a slight movement of depression has drowned a number of low valley floors, producing shallow arms of the sea, as Chesapeake Bay, Albemarle and Pamlico Sound, and Mobile Bay.

The Cordilleras of North America.

The great complex of mountains in the Western highlands, sometimes styled the Cordilleras of North America (the Rocky Mountains being the eastern members of the system in the United States and Canada), differ from the Laurentian and Appalachian regions in having suffered numerous disorderly movements at dates so recent that the existing relief of the region bears a significant relation to its irregular uplifts; a relation that doubtless once obtained in the older mountain areas of the east, where it has now been obliterated by erosion. It is not, however, only in modern geological periods that mountain-making disturbances have prevailed in the regions of the Western highlands; their geological history is one of repeated and long continued movement—the ruins of the more ancient upheavals supplying materials for the strata of newer ranges. For example, in Canada an axial belt of ancient rocks is bordered on the east and west by stratified formations of enormous thickness (40,000 to 60,000 feet), those on the west including a large share of contemporaneous volcanic materials; all three belts having been deformed and upheaved, as well as deeply dissected in the later chapters of geological time. It is, however, important to note that the interval between Palæozoic and Mesozoic time, in which mountain-making disturbances were so general in western Europe and eastern North America that the older geologists thought them to be of world-wide extent, was here generally passed over in relative quiet, so that continuous sedimentation produced in certain districts a conformable series of deposits from Silurian to Cretaceous time. Furthermore, the Carboniferous period, which gained its name from the extensive coal deposits that were then formed in western Europe and eastern North America, was a marine limestone-making period in the Cordilleran region. If the science of geology had had its origin on the Pacific side of America, some of its early generalizations would have been very different from those which gained credence in the lands bordering the North Atlantic.

There is here exemplified, as might be expected in a region extending over 3000 miles from Alaska to southern Mexico, and measuring over 1000 miles in breadth at its middle, a great variety of plateau and mountain structures. The broad upheaval of adjacent blocks of earth-crust without significant tilting or disturbance has produced the plateaus of Arizona and Utah. Some of the simplest and youngest mountain ridges in the world are to be found in the broken and tilted lava blocks of southern Oregon. Tilted blocks on a larger scale, much more affected by processes of sculpture, are found in the lofty St Elias

Alps of Alaska, the site of some of the greatest glaciers in the world. The wall of a huge fracture, now elaborately carved, constitutes the western slope of the Wahsatch range, facing the desert basin of Utah. Ranges of a relatively simple arch structure are seen in the Uinta mountains of Wyoming and Utah. Arched upheavals also characterize the front range of the Rocky Mountains proper in Colorado and Wyoming and in the Black Hills of South Dakota, bending up the strata of the adjacent plains in the simplest fashion, and producing dome-like mountains, now deeply dissected by outflowing consequent streams. A remarkable change occurs in the structure of the Rocky Mountains north of the Missouri river in Montana and northward into Canada, where the front range is of synclinal or trough structure, with the youngest instead of the oldest rocks along the axis, while the strata of the plains are bent down and overridden in the most abnormal manner. Indeed, mountain structure occurs of so great diversity in various parts of the Cordilleran region as to elude general description. The disturbances extend directly to the western coast line, including not only the coast range of California, but the peninsular area of Lower California (belonging to Mexico) and the detached mountainous islands of British Columbia and Alaska.

Volcanoes of commanding form here and there dominate the plateaus and mountains. Orizaba, Popocatepetl and their neighbours, terminating the Cordilleran system in Mexico; Mount San Francisco, bearing snow and Arctic plants above the nearly desert plateau of Arizona; Mount Shasta, with small glaciers in northern California; Mount Rainier, with extensive glaciers surmounting the Cascade range of Washington; Mount Wrangell in Alaska, and farther on the many cones in the curved chain of the Aleutian islands: all these have been heaped up around vents through which their lavas rose from some deep source. Vast lava floods have been poured out at different times. Extensive lava beds, barren and rugged, cover large areas in north-eastern California. The basins of Snake and Columbia rivers in Idaho and Washington are flooded with older and more extensive lava sheets, whose borders are varied by promontories and islands of the "mainland." Still older lava flows in British Columbia are now deeply dissected by the branches of Frazer river, and remain only in disconnected upland areas. High plateaus in Utah are protected by a heavy lava capping, the result of great eruptions before the plateaus were uplifted. Here and .there rise dome-like mountains, the result of the underground intrusion of lavas in cistern-like spaces, forming "laccoliths," and blistering up the overlying strata. Thus, by mountain upheaval or volcanic eruption, great altitudes have been gained. Where the uplift has been strong, ranges of truly Alpine form with extensive snow-fields and glaciers occur, as in the Selkirk range of Canada (now traversed by the Canadian Pacific railway), and again in Alaska. Heights of 12,000 and 14,000 feet are exceeded by numerous summits in the central part of the system; but the dominating peaks are found far in the north-west and in the south. Several mountains in Alaska exceed 18,000 feet (Mount McKinley, 20,464 feet; Mount Logan, 19,500 feet; Mount St Elias, 18,024 feet); and the great Mexican volcanoes rise nearly as high (Orizaba, 18,250 feet). Widespread plateaus maintain upland altitudes of more than a mile over vast areas.

As in all regions of great altitude, the erosion of valleys has progressed on a magnificent scale in the Cordilleran region, and the actual form of many of its parts is more the result of sculpturing than of uplifting. The plateaus of Arizona are traversed by the deep cañons of the Colorado river and its branches, at places a mile deep, and with elaborately carved walls, from which the most impressive lessons have been learned regarding the origin of valleys by river action. Upon the plateaus themselves, long and ragged cliffs of recession attest an even greater work of erosion than the cañons. In all the mountain ranges except those of youngest uplift, valleys have been actively eroded, sometimes producing steep peaks as in Mount Assiniboine (11,500 feet) in the Canadian Rockies, rivalling the Swiss Matterhorn in sharpness of form; but the greater number of summits have been worn to roughly pyramidal form between wide-flaring valleys, and the mountain flanks have thus come to be extensively covered with rock waste lying on slopes of relatively uniform declivity. Some of the ranges are in a second cycle of dissection, having been once worn down to moderate relief and now being elevated for renewed erosion; the Sierra Nevada of California is believed to be, in part, of this history, having at least in its central and northern parts been well reduced and now again enjoying a mountainous character in virtue of a later slanting uplift *en bloc*, with rapid descent on its eastern fractured face. Other ranges, almost completely worn down, still remain low, as in south-eastern California, where they are now represented by gently sloping rock floors veneered with gravel and retaining only small remnants of their original mass still unconsumed; thus the end, as well as the beginning, of the cycle of erosion, together with many complications of its progress, are illustrated in different parts of this great and varied mountain system. In the fiorded coast of Alaska, signs of intense glacial erosion are seen in the discordant junction of the "hanging" lateral valleys and the deep trunk valleys—the floors of the former being cut off on the walls of the latter.

Fitting complements of the deeply-eroded mountains are found in the great accumulations of mountain waste now occupying basins of depression between the various ranges, as in Mexico, Utah, Nevada, Montana, and elsewhere. Erosion and transportation here combine to build up the floors of the basins with the waste of the surrounding highlands; a result that is peculiarly beneficial in Mexico where the climate of the plateau basin is rendered relatively temperate by reason of its altitude, and where the surface is easily habitable by reason of its smoothness. In the larger depressions, as along the boundary of the United States and Mexico, isolated ranges frequently rise like islands over the plain of waste that has been built up on their flanks. Shallow saline lakes or playas (wet-weather lakes) without outlets lie on the lowest parts of the waste-filled basins; their failure to overflow in rivers discharging to the sea being less the result of enclosure by barriers than of deficiency of rainfall; for it is chiefly in the arid region that the waste-floored basins are best developed. Indeed, the rainfall is often so scanty that the streams from the mountains—where most of the little precipitation occurs—often fail even to form lakes, withering away on the waste plains. In all these cases, the wash of rock waste from the mountains remains on the continent and builds up the basin plains, instead of being carried away from the land to form stratified sediments on the sea floor. The habit of gathering mountain waste in interior basins that characterizes so much of the Cordilleran region to-day is only the continuation of an earlier practice, for extensive basin deposits of Tertiary date are found in many parts of the Cordilleran region; some of them are famous for preserving vertebrate fossils, such as those of the many-toed ancestors of the horse.

Between the loftier Western highlands and the lower Eastern highlands (Laurentian and Appalachian) lies a great extension of Medial plains, stretching in moderate altitude from the Arctic Ocean to the Gulf of Mexico,

The Medial Plains.

and having in their middle a breadth of 1500 miles. They are composed throughout of nearly horizontal strata and mark a region long exempt from strong disturbance. Although for the most part floored by marine formations, their structure and composition indicate, as has already been said, relatively shallow water. The ancient sea that once occupied the middle belt of the continent therefore had little likeness to the abysmal oceans, but resembled rather the shallow ocean margins that to-day overlap various continental masses—the largest example of this kind now existing being between Asia and Australia. The eastern part of the plains is underlaid by Palæozoic strata, already mentioned as having been laid down upon the subsiding Archæan continent or folded in the making of the Appalachians; coal beds are here included in the Ohio and middle Mississippi basins. The area of the western plains remained submerged to a later date preserving a stretch of marine waters to the end of Mesozoic time, and thus resembling the lowland belt of western Asia, which was similarly covered by a broad and a shallow arm of the ocean extending from the Arctic to the European mediterraneans until a late geological date. The surface of the Medial plains is not always so even as might be inferred from their name. Both the eastern and the western areas have been extensively denuded, even to the point of being reduced to lowlands of denudation. Their present altitude is not so much the result of their original uplift from the sea as of a later elevatory movement. The great river basins, for which North America is famous, have thus been formed between the Eastern and Western highlands—the Mississippi receiving the drainage of a vast area (about 1,240,000 square miles) for discharge to the south, while the Saskatchewan and Mackenzie gather their waters from somewhat less extensive areas in the north. Pleistocene glaciation covered the plains of the Ohio, upper Mississippi and Winnipeg districts with extensive deposits of ice-laid or water-laid drift, furnishing a generally smooth surface and a fertile soil: here are the true prairies—treeless, but richly grassed.

Central America and the West Indies.

The traditional continuity of the Cordilleras of North and South America has been broken by investigations in the isthmian portion of the northern continent. The structural peculiarities of the Western highlands of North America may be traced only to the east and west belt of great volcanoes by which the plateau of central Mexico is terminated on the south. The ranges of the Andes fail to reach Panama, from which the nearest one is separated by the valley of the Atrato. The two Cordilleras are out of line with each other, and their ends are some 1200 miles apart. Central America, the West Indies, and various submarine ridges by which they are connected with one another and with the mainland to the west, as well as certain ranges along the northern margin of South America, all belong together in what has been termed the Antillean mountain system, in which east and west trends of late geological date predominate, with abundant volcanic additions on the Pacific border of Central America, and along the eastern end of the system in the Windward islands of the Lesser Antilles. The unity of this system has been until recently overlooked partly because the Antillean ranges are for the most part still under water, and yet further because the volcanoes which form the strongest reliefs of the isthmian region are so arranged along the Pacific coast as to suggest the continuity of the Cordilleran systems on the north and south; but these volcanoes are really only superadded to a foundation of quite another kind. Geological studies on the mainland and on the islands have shown that both fundamental structure and surface form are not Cordilleran; and numerous soundings in the adjacent mediterraneans suggest that the islands are best interpreted as the somewhat denuded crests of great crustal ridges. The warm waters that bathe the West Indies come with a high temperature from the equatorial Atlantic, and favour the growth of corals along the shores. Fringing and elevated reefs are known on many of the islands. The Bahamas are the slightly overtopping parts of a broad platform of coral and other calcareous marine deposits, of which the greater area constitutes extensive shallow banks, which descend by a steep slope on the north-east to great depths in the Atlantic. The lowlands of Yucatan resemble Florida in being the emerged part of a much larger mass, of which an equal portion is still under water in the shelf around the Gulf of Mexico. All this region is luxuriantly productive and is advantageously surrounded by waters which would be barren and desert if replaced by lowlands. The active volcanoes on the Pacific slope have built many cones and uplands, some of their historic eruptions having been of terrible violence. Thus Lake Nicaragua, once a bay of the Pacific, has been cut off by volcanic deposits, leaving only the Gulf of Fonseca open to the western ocean, raising the level of the lake behind the barrier and turning its discharge eastward to the Caribbean Sea across what was once the inter-oceanic watershed.

Rivers.

The successive crustal movements by which the land area of what we now know as North America has been increased and connected have determined the growth of several great river systems through which the broader part of the continent is drained. The movements that resulted in the emergence of the Plains had the effect of engrafting many ancient rivers of moderate size upon trunks of unusual dimensions. The Mississippi system, some of whose eastern branches probably date from early Mesozoic time, received great reinforcements by the addition of many long western branches in Tertiary time, roughly contemporaneous with the uplift of the Gulf coastal plain by which the lower trunk of the river was extended to the sea. The present headwaters of that stream to which the *name* of Mississippi is applied, and which for that reason have gained an undue subjective importance, are of relatively modern date, as they are controlled by the abundant glacial deposits of northern Minnesota. The evolution of the Mackenzie resembles that of the Mississippi in a very general way, although some of its eastern branches may be the descendants of ancestors more ancient than those flowing westward from the Appalachians; but the *régime* of the great northern river is strikingly unlike that of its still greater southern analogue on account of its course being from a warmer to a colder climate: hence ice-dams, obstructed discharge, and overflows. The Nelson and the St Lawrence systems, draining eastward to Hudson Bay and St Lawrence Gulf, receive drainage from areas that would belong to the Mackenzie and the Mississippi systems under a simpler plan of continental growth; and there is much reason for thinking that this simpler plan obtained until the occurrence of those changes, in association with the Glacial period, whereby sea waters gained access to the depressions that now hold the bays and sounds of the north-eastern coast. In exemplification of the rule that the larger ocean receives the drainage of the smaller continental area, the rivers that flow into the Pacific rank below those belonging to the Atlantic. The greatest is the Yukon, of farther Canada and inner Alaska, one of the great rivers of the world, little known until the recent active exploration of its basin for gold fields. The Frazer drains much of the mountainous area of southern British Columbia, as the Columbia drains that of the north-western United States;

the latter is peculiar in that one of its headwaters rises at the *eastern* base of the Rocky Mountains in northern Montana. The Colorado discharges a muddy current into the Gulf of California; but for the aridity of its large drainage area its volume would be much larger. The same is true of the Rio Grande, whose name would be better justified if so much of its basin were not semi-arid.

Lakes.

The references already made to lakes may now be reviewed and summarized. Several lake districts may be mentioned. The most remarkable lacustrine region of the continent, rivalling that of central Africa, forms a belt around the border of the Laurentian highland; here, in addition to ten large lakes, there are hundreds of medium size, and many thousand small lakes. They are peculiar in occupying a region of moderate relief, in which no strong dislocations have taken place in recent geological time (unless in the case of Lake Superior), and thus in contrasting with the great African lakes which occupy rift-valleys or *graben* of comparatively recent fracture. The Laurentian lakes are further characterized by an intimate association with the ice-sheets of the Glacial period; but while glacial erosion and drift obstruction suffice to account for the smaller lakes, it is very probable that broad crustal warping and drainage reversal have been potent aids to the other processes in producing the great lakes. The northern Cordilleran region contains many beautiful lakes of moderate size in deep valleys among the crowded ranges of the narrowed mountain belt. Their origin has not been closely studied. The basins among the spaced ranges of the middle and southern Cordilleras, in the United States and Mexico, contain many lakes that occupy shallow depressions in desert plains; they are usually without outlet and saline; many of the basins were formerly occupied by lakes of much greater size, some of which overflowed, implying a climate moister than that of to-day, probably correlated with the glacial climate of the regions farther north. Lakes in volcanic craters or behind volcanic barriers occur in Central America, while Florida possesses many small lakes in limestone basins. The following table is taken from Russell's *Lakes of North America*:—

Lake.	Altitude.	Area.	Depth.
	Feet.	Square Miles.	Feet.
Ontario	247	7,200(?)	738
Erie	573	9,900	210
Huron	582	22,322	750
Michigan	582	21,729	870
Superior	602	31,000(?)	1008

Climate.

The climatic features of North America are best appreciated when considered as exhibiting modifications of those general climatic conditions which prevail in consequence of the globular form of the earth as a whole. In January, when the isotherms of 65° to 75° F. stretch almost directly across land and sea in the torrid zone, a mean temperature of zero or less invades the region north-west of Hudson Bay, which thus resembles north-eastern Asia in departing greatly from the mean prevailing in similar latitudes on the northern oceans, and in bringing upon the northern lands an extension of frigid conditions that have no analogue in the southern or oceanic hemisphere. In July, when the isotherms of 40° and 50° have a tolerably direct course around the latitude circles that border the continent on the north, a great middle area of North America becomes warmer than the seas on the east and west, having a mean of over 80°, and in part over 90°. In January, the Hudson Bay region is 30° colder than the mean of its own latitude, about 60° colder than the mean of the corresponding southern latitude; while in July the Arizona-Mexican region is 20° above the mean of its own latitude, or about 40° above the mean of the corresponding southern latitude. In both winter and summer the isotherms are more closely crowded while crossing the continent than while crossing the adjacent oceans; or, in other words, the poleward temperature gradient is stronger on the land than on the oceans; and all these features should be regarded as inherent characteristics of the climate of North America in virtue of its being a continent chiefly in temperate latitudes.

An associated feature of continental climate is found in the strong annual range of temperature of the central land area. The range between the means of January and July exceeds 40° for the largest part of the lands, and 70° for much of the northern lands; the range of extreme temperatures is much greater. On corresponding oceanic areas in the northern hemisphere the range is little more than 20°, and in the southern hemisphere it is probably less than 10°. It must appear from this that if the largest part of North America is said to be in the north temperate zone, "temperate" must be taken as having little of the meaning originally given to it in southern Europe, for the winter cold is severe and the summer heat is excessive over much of the North American continent. In this respect two more unlike belts can hardly be found than the north and south temperate zones, in spite of the resemblance that is implied in their names.

The several members of the terrestrial wind system, including therein the trade winds of a broadened torrid zone, the stormy westerly winds of middle latitudes, and the irregular winds of the polar regions, are well exemplified over North America; but, as is usually the case on land, the systematic movement of the atmosphere is better seen in the drift of the clouds than in the movement of the surface winds, which are much modified by the changes from hill to valley, from mountain to plain. Nevertheless the prevalence of the general atmosphere currents has much to do with the control of certain values of annual temperature range, as well as with the distribution of rainfall. The former are small (about 20°) along a great stretch of the Pacific coast, even as far north as Alaska, where the moderating influences of the ocean are brought upon the land by the westerly winds; while a range appropriate to a continental interior (30° or 40°) is experienced over most of the eastern side of the continent in temperate latitudes, and even upon the North Atlantic ocean near the American coast, where strong seasonal changes of temperature are carried forward by the westerly winds. It is particularly in this respect that the general climatic resemblances between North America and Eurasia, above referred to, are broken; for eastern Canada and western Europe are strikingly unlike in seasonal variations of temperature. Labrador is about 10° cooler than northern Germany in July, but nearly 40° colder in January.

The distribution of rainfall is in general controlled by the prevailing course of the winds. The West Indies receive abundant rain from the passing trades. In Mexico and Central America the eastern slopes are for the most part better watered than the western, because the winds there come chiefly from the east (maximum over 100 in. in Guatemala and adjacent parts). Farther north the reverse holds true; the Pacific slope north of 40° latitude has an abundant rainfall (maximum over 100 in.), and its mountains are clothed with dense forests. There are large areas of deficient rainfall (less than 20 in.) in the interior of the continent, where the intermontane basins and the piedmontese plains that slope eastward from the Rocky Mountains in middle latitudes are treeless. The areas afflicted with dryness are unsymmetrically distributed, being west of the Medial meridian (95°), because of the ranges near the Pacific by which rain is withheld from the basins and from the plains farther east. The dryness is induced not only by light precipitation, but also by active evaporation in the warm season—a rule that holds true until a high latitude is reached. East of the medial meridian great profit is received from the warm and moist winds that are drawn inland from the water surface of the mediterraneans which so advantageously occupy the latitudes that are given up to the Sahara in the Old World. It is largely on this account that the central and eastern parts of the Mississippi basin enjoy a sufficient and well-distributed rainfall, producing forests or fertile prairies over great areas (rainfall over 40 in.). Regions of prevailing snowfall are chiefly in the north-west and north-east; the former includes the higher ranges of the Western highlands in Canada and Alaska, where the snowfall from the Pacific winds is heavy, and extensive snowfields and glaciers are formed; the former includes Greenland, where a heavy ice-sheet shrouds the land, the snowfall of moderate measure being probably supplied mostly from the relatively warm waters of the North Atlantic. In the northern continental interior snow covers the ground during the winter season, not that the snowfall is heavy but that the persistent cold weather preserves the moderate amount that falls.

The extension of the continent across the belts of the terrestrial wind system tends to turn branch winds from the westerlies toward the trades on the Pacific border, and from the trades toward the westerlies on the Atlantic border. This effect is strengthened in summer, when the higher temperature prevalent over the continent causes the air to flow away from above the lands, and to accumulate over the neighbouring oceans, on each of which a vast anticyclone is thereby established,—the circulation of the atmosphere over the North Atlantic and North Pacific thus coming to simulate the circulation of the surface waters of the oceans themselves. It is partly on account of this deflection of the summer winds up the Mississippi valley that the eastern interior of the continent receives a beneficent rainfall as already stated. In winter when the inflow from the south is replaced by an outflow, little rain or snow would fall but for the indraft winds of cyclonic storms by which the outflow appropriate to the cold season of the continent is temporarily reversed. The free play of the winds north and south over the great Medial plains permits indrafts from torrid and frigid sources, which sometimes succeed each other rapidly, producing abrupt and frequent weather changes. Something of the same contrasts is produced by winds drawn in upon the eastern coast alternately from over the moist and warm waters of the Gulf Stream, and from over the moist and cold waters of the Labrador current.

The southerly flow of the branching winds along the Pacific coast gives them a drying quality, and thus still further broadens the western arid region towards the ocean until it reaches the coast in southern California and north-western Mexico (rainfall less than 10 in.), there joining the arid belt of western Mexico, and presenting a strong contrast to the rainy forested coast farther north; but although unfavourably dry, the southern California coast is one of the most truly temperate regions of the world, in respect of mildness and constancy of temperature. The drying winds cover all California in summer, but they migrate southward in the winter, giving place to the stormy westerlies. Thus California has a subtropical climate of wet winters and dry summers; while north in British Columbia and Alaska there is plentiful rainfall all the year round, and farther south there is persistent aridity.

Fauna. The fauna of North America (Nearctic) is more closely related to that of Europe-Asia (Palæarctic) than to that of any other zoogeographical province; the two being united by many writers in one faunal province (Holarctic). The reindeer (caribou), beaver, and polar bear are common to both provinces. The moose, wapiti, bison, and grizzly bear of North America are closely related to the elk, red deer or stag, aurochs, and brown bear of Eurasia; and the following groups are well represented in both provinces: cats, lynxes, weasels, bears, wolves, foxes, seals, hares, squirrels, marmots, lemming, sheep, and deer. On the other hand the following forms are characteristic of North America: (*rodents*) pouched rats or gophers, musk rat, prairie dog, Canadian porcupine; (*carnivora*) raccoon and skunk; (*ungulates*) musk ox, bighorn, Rocky Mountains goat, pronghorn; (*marsupial*) opossum. Among birds there is a close resemblance to those of Eurasia, with some admixture of South American forms, as in the humming birds. The forms especially characteristic of the northern continent are the Baltimore oriole, bobolink, cowbird, flycatchers, woodwarblers, Californian quail, tree grouse, sage grouse, wild turkey, and turkey buzzard. The house sparrow of Europe has been introduced, and has become very common, especially in the cities, where it is known as the English sparrow. Reptilian and amphibian groups are well represented; turtles are especially numerous; salamanders are varied and large; rattlesnakes are among the more peculiar forms. Among fish, the characteristic forms are the cyprinoids (carp), sturgeon, salmon, pike, and especially the suckers, sunfish, mudfish (*Amia*), and gar pike (*Lepidosteus*). The most characteristic group of invertebrates is the Unionidæ or river mussels.

Flora. The floral areas of North America, limited by the geographic divisions of the continent, may be divided into five belts: the eastern forested area, the western forested area, the interior unforested area, the northern barren lands, and the Gulf coast. The eastern forested area extends from the Laurentian highland in Canada to the Great lakes, and southward east of the Mississippi to the Gulf coast. In the north and along the mountains southward, the forests are largely coniferous, with a mixture of birches, poplars, and maples. Southward, especially in the interior and at low altitudes, the conifers largely disappear, and oaks, hickories, plane-trees, tulip-trees, walnuts, and other valuable deciduous species abound. Throughout this belt lumbering is an important industry. The western forested area begins in the eastern Rocky Mountains, and extends to the Pacific. Eastward in the mountains the forests are interspersed with arid districts which increase in area southward. Northward, in Canada, the mountains of the middle Cordilleras are densely wooded with continuous forest. Near the middle Pacific coast the forests attain a luxuriant development, the redwood (*Sequoia*) of California and Oregon sometimes reaching a height of from 300 to 400 feet. In this western forested area lumbering is extensively carried on. The unforested area of the interior consists of two very dissimilar portions. The vast fertile prairies extend from the Great lakes westward to the Great plains, and southward west of the Mississippi, with occasional eastward lobes at low altitudes. On these plains grasses and other herbaceous vegetation abound, and throughout this fertile belt agriculture is largely followed, the grain and hay crops being especially important. Northward in Canada the plains become wooded, the western mountains and the eastern highlands being thus connected by a narrow strip of forest. Southwestward and westward the fertile prairie gives way to a vast arid region beginning on the Great plains and extending as far as south-eastern California, and thence southward into Mexico. On this broad desert few trees are found, although piñons grow on the cliffs and ledges, and cottonwoods occur along the watercourses. The vegetation as a whole consists of cacti, agaves, sage-brush (*Artemisia*), and other plants adapted to arid conditions. North of the eastern forested area and east of the northern Cordillera are the "barren lands," with frozen subsoil, extending thence to the Arctic coast. The growing season here is short and the climate forbidding, so that trees cannot develop, although birches, poplars, willows, and other genera, which southward attain great size, are present as dwarf shrubs. The vegetation of this northern barren district, like that of bleak mountain summits southward, is very similar in character to that of other extreme boreal regions. Blueberries, crowberries, and some other small fruits are abundant, but the brief summer will not mature most crops of the temperate zone. The Gulf coast, on the other hand, supports a vegetation decidedly tropical in its nature. Somewhat developed in Florida and the other southern states, this flora becomes the prevailing one on the coast of Mexico and Central America, especially from the region of Vera Cruz southward, where the forests are largely composed of palms and live oaks, and where giant bamboos often attain a height of 40 feet. In these tropical forests many orchids and other showy plants of northern conservatories are native.

Economic development of the continent.

North America, with an area of about 8,000,000 square miles (16 per cent. of all the lands, or 4·12 per cent. of the whole earth's surface), and a mean altitude of about 2000 feet, at present plays a part in human history that is of greater importance than is warranted by its size alone, although it has not in this respect the extraordinary importance of Europe. The continent has the good fortune to lie chiefly in a temperate rather than a torrid zone, and in temperate latitudes to be much nearer to Europe than to Asia. Whatever may have been the first home of the aboriginal inhabitants, the dominating people of to-day are derived from the leading countries of the Old World. Not only so, temperate North America has become the most progressive part of the continent because of receiving its new population chiefly from the most advanced nations of middle western Europe—Great Britain, France and Germany; while the torrid islands and the narrowing southern mainland of North America have been settled chiefly from the less energetic peoples of southern Europe; and the inhospitable northern lands are hardly entered at all by newcomers, except in the recently-discovered gold fields of the far north-west. From the plantation of colonies on the eastern coast, the movement inland has been governed to a remarkable degree by physiographic factors, such as form, climate, and products. The cities of the Atlantic harbours and of the adjacent lowlands still take a leading part in industry and commerce, because of their longer establishment and of their relation to Europe. The uplands, ridges, and mountains of the Appalachian system—the "Backwoods" of a century ago—still remain rather thinly occupied except at certain centres where coal or other earth-product attracts an industrial population. Beyond the Alleghenies, the middle interior contains a very large proportion of habitable land. It was long ago recognized as a land of great promise, and it is to-day a land of great performance, covered with a wonderful network of single-line railways, yielding an enormous product of grain, and developing industries of all kinds towards a future of rapidly increasing power. Indeed, within and closely around an area marked by the St Lawrence system on the north, the Ohio on the south, and stretching from the Atlantic coast between the Gulf of St Lawrence and Chesapeake Bay inland to the middle prairies, there is a remarkable concentration of the population, industry, progress, wealth, and power of North America—the focus of attention from all other parts of the continent. The regions of the far north and north-east, including the greater part of the Laurentian highland and the extreme northern stretch of the Medial plains and the Western highlands, remain and will long remain thinly populated. The furs of wild animals are their characteristic product. Timber is taken from their more accessible forests; but only in mining districts does the population notably increase, as in the iron region around Lake Superior and in the recently-discovered Klondyke gold region.

In the south-eastern United States lies a belt of coastal lowlands skirting the Appalachians, long blighted by negro slavery and still suffering under its consequences, not only because the institution of slavery demanded the importation of African savages, but even more because its perpetuation held the slaves in ignorant poverty and made labour disgraceful, and still more because its abolition has not yet removed the race prejudice under which the progress of the negro, even only to political equality with the whites, is so long delayed. This is nowhere the case with European immigrants of whatever nationality or religion. The descendants of the early French settlers of Canada stand in political rights as well as in loyalty to the Government on an equal footing with the British citizens of the Dominion. The Italians of the cities, the Hungarians of the mines, the Scandinavians of the northern prairies, the Irish and Germans everywhere are "Americanized" in the second or third generation, rapidly entering local and national politics, and hardly less rapidly attaining an honourable social standing as tested by intermarriage with English and other stocks. But the negro is set aside, even though he has adopted the language and the religion of his former masters: political and social rights are denied him, and intermarriage with whites is practically excluded, although mulattos are numerous. Thus has slavery left upon a people, amongst whom political rights and social opportunities should be equal for all, the heavy burden that has always retarded progress where strongly contrasted races are brought together. Farther south still are the tropical islands and the narrowing mainland, rich in possible productiveness, but slowly developed because of a prevailing diversity and instability of government and lack of progressive spirit among the people. Here also there is a considerable proportion of negroes, but they live under less unhappy conditions than those now obtaining in the United States.

West of the Mississippi in middle latitudes the population rapidly decreases in density, and over a large extent of the semi-arid plains it must long remain sparse. The settlements bordering the plains on the east longitude for a time marked the "Frontier" of civilisation, for the vast stretch of dry country was a serious barrier to farther advance. But the plains are now crossed by many railways leading to the Cordilleran region—the "Far West"—in large part too rugged or too arid for occupation, but rich in minerals from one end to the other, the seat of many mining camps of unstable population, and containing numerous regular settlements in the intermontane basins. On nearing the farther ocean the climatic conditions improve, and the population is rapidly increasing in number and wealth; this district not being content to take its name with respect to the east, not considering itself as included in the "Far West," but choosing the distinctive designation of the "Pacific Slope," and, while maintaining an active intercourse all across the breadth of the continent, already opening relations with the distant Orient by a new approach. Among the earliest results of the latter movement was the arrival of Chinese labourers, a humble, industrious, and orderly class of men, but one which stands apart in language, religion, and race from the dominant population, lives largely without domestic ties, and gains neither political nor social standing in the New World.

Two hundred years ago the aboriginal population of North America would have deserved description before the immigrant population. To-day the aborigines are displaced from all the most valuable parts of the continent. Never very numerous, they are now decreasing; many tribes are already extinct, many more are almost so. Those which remain less diminished are in the Far North or North-West, where nature is rigorous; or in the tropical forests of Central America where nature is overbounteous; or in the more desert parts of the Middle West where nature is arid. The replacement of the native races by the foreign has too often been harsh, cruel, and unjust; yet it has resulted in an advance of civilization. Many savage tribes, speaking many different languages, holding little intercourse with each other, and frequently engaged in intertribal wars, have given place in little more than two centuries to a great population of European origin, whose dominant parts speak one language, whose arts are highly advanced, whose home intercourse is most active, and whose foreign commerce has attained unexpected proportions at the opening of the 20th century. (W. M. D.)

SOUTH AMERICA.

Geology.

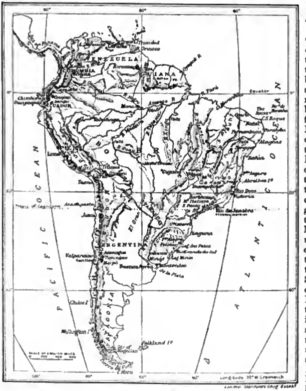
Granites and gneisses, supposed to be of Archæan age, occur at many places along the east side of the Andes, in the highlands of Venezuela and near the coast about Caracas. There is a more or less continuous area of granites along the watershed between the Amazon and Venezuela and the Guianas extending from the fall line on the Cunani, and the Araguay on the east to the mouth of Rio Meta on the Orinoco, and the mouth of the Uaupés on Rio Negro. In this region the granites are overlapped in many places by more recent beds of unknown age. In the highlands of Brazil south of the Amazon they are found at the falls of the Madeira river, on the Tapajos, at the falls of the Xingú on the south side of the Amazon valley, and along the eastern border of the continent, with certain short interruptions from Maranhão, Brazil, southward to Montevideo, at the mouth of the Rio de la Plata. The largest of these granite areas is the one along the east coast and in the highlands of Eastern Brazil, but even here it is more or less irregular in outline, and its exact limits are unknown except on the immediate coast. Associated with the granites and gneisses is a series of metamorphosed beds exposed over a still larger area. These include schists of various kinds, itacolumites, itabirites, slates, quartzites, and marbles. The series is more or less folded, faulted, veined, and cut by old eruptives. The age of these beds has never been definitely determined, for they have thus far yielded no fossils. In many places they bear a strong resemblance to the Algonkian series of North America, but their position would admit equally well of their reference to the Cambrian. In this series occur most of the mineral deposits of the eastern part of the continent—the gold veins of Venezuela, of the Guiana highlands, and of the gold regions of Brazil, and also the iron, manganese, diamonds, and topazes of Brazil.

Rocks of Silurian age have been found in the Amazon valley, on the north side of the river east of Manaos; in Bolivia, along the eastern slope of the Andes and near Cuyabá, about the headwaters of the Rio Paraguay. It is quite possible, even probable, that many of the unfossiliferous beds, now provisionally referred to the Cambrian, are of Silurian age. The Amazon river along its lower course, that is, east of Manaos, flows through a Devonian basin filled with rocks of later age. Near longitude 55°-56° W., Devonian rocks outcrop on both sides of the stream a little more than a hundred miles away from it. It is improbable that this Devonian basin extends far up the Amazon valley, for there are metamorphic rocks on the Rio Negro, a short distance above Manaos. In the highlands of Matto Grosso, Brazil, just east of Cuyabá, Devonian rocks cap the hills. Devonian beds are known in Bolivia along the eastern slope of the Andes, and it seems probable that they extend north and south along the range for a long distance. In the state of Paraná, Brazil, a belt supposed to be of Devonian age crosses the state from north to south (Derby), dipping westward beneath a series of rocks referred to the Trias.

The known areas of Carboniferous rocks in South America are small—one basin underlying the Lower Amazon valley contains marine fossils, having a Permian facies. Carboniferous rocks of about the same geological horizon are known also from the vicinity of Lake Titicaca in Bolivia. In the state of São Paulo, and extending into the adjacent states of Minas Geraes and Paraná, is another Carboniferous or possibly Permian basin, but the fossils are scarce and are not marine. The western and southern limits of this São Paulo basin are not known at present. In the southernmost states of Brazil, namely, in Santa Catharina and Rio Grande do Sul, there are at least six separate basins in which coal of Carboniferous age occurs. One of these basins is on Rio Tubarão, near Laguna, Santa Catharina; another is on the Rio Verde, the line between Santa Catharina and Rio Grande do Sul. In Rio Grande do Sul there is one coal basin at Candiota on the railway leading from Pelotas to Bagé, another near the south end of Arroyo dos Ratos, one 100 miles in length lies along the south side of Rio Vacacahy, and another is just west of the city of Porto Alegre. Overlying the rocks of Carboniferous or Permian age in Minas, São Paulo, and Paraná, Brazil, is a series of sediments and eruptives that have been referred provisionally to the Triassic. Thus far no fossils have been found in them. Rocks believed to be of Triassic age occur in Paraguay, near Diamantino, in the states of Matto Grosso, Brazil, and in Chile and Bolivia. Jurassic rocks are found in Chile, Bolivia, Peru, and the Argentine Republic, and it is possible that some of the Brazilian rocks previously referred to the Triassic belong to the Jurassic.

Rocks of Cretaceous age cover a large area in the interior of the states of Ceará, Piauhý, Parahyba, and Pernambuco in Brazil, while on the coast of the states of Sergipe and Alagôas there are Cretaceous beds containing an abundance of marine fossils. Cretaceous rocks are found in Tierra del Fuego, in Southern Patagonia, in the province of Santa Cruz, Argentine Republic, and they extend northward along the eastern flank of the Andes, with interruptions through Ecuador, Colombia, and Venezuela. On the west side of the Andes a narrow belt of Cretaceous extends nearly or quite the whole length of the continent. The coal or lignite beds of Southern Chile are in the Laramie of the upper Cretaceous. Cretaceous rocks cover a part of the island of Trinidad, off the north coast of Venezuela, and the same Cretaceous basin extends over a part of the Venezuela mainland. The rocks of this age on Trinidad are of organic origin, and it is from these that the remarkable pitch deposits of that island have been derived.

Eocene Tertiary beds occur on the island of Trinidad and on the Venezuela mainland, but it is not known how far these beds extend to the south along the eastern border of the continent. Just south of the Rio Oyapok granites are exposed on the lower courses of the streams, but on the lower part of the Rio Araguay sedimentary beds form low hills, and extend along both the north and south sides of the Amazon valley for hundreds of miles. These beds have generally been regarded as Tertiary, but they have yielded no fossils, and their age is not known. There are fossiliferous Tertiary beds of brackish water origin in the Upper Amazon valley covering a large area, extending westward from Tabatinga, on the Brazilian frontier. Tertiary beds form a narrow belt along the coast of Brazil, probably from the Amazon valley to near Victoria in the state of Espirito Santo. This belt is a hundred miles wide at some places, while at others it is only a fraction of a mile in width, or is entirely wanting. At and for some miles north of Pernambuco the fossiliferous portions of these beds show them to be of marine origin; south of Pernambuco, on the coast of Alagôas and in the state of Bahia, they are of fresh-water origin. The sandstone reefs of the Brazilian coast, the elevated beaches of Bahia and Rio de Janeiro, and the older parts of the coral reefs, may possibly be of late Tertiary age. Beds known to belong to the Tertiary spread over a wide area in the valley of the Rio de la Plata, and over the lowlands of Eastern Argentina and Patagonia. On the west coast Tertiary rocks form much of the narrow plain between the Andes and the ocean, and there are besides isolated Tertiary basins in the high parts of the mountains.



Sketch Map of South America.

Some of the eruptive rocks of the Andes are post-Tertiary, while others are pre-Tertiary. The eruptives of the Paraná basin are newer than the Trias, but their age has not as yet been more precisely determined. All through the highlands of Venezuela, the Guianas, and Brazil, the older Palæozoic rocks are extensively cut by eruptives. Along the north-eastern and south-eastern sides of the continent, most of these eruptives are pre-Tertiary. In only one place—on the Abrolhos Islands—is there a dyke known to be in rock of Tertiary age, while the island of Fernando de Noronha is the only place on the eastern side of the continent at which a volcano of late geologic age is known to have existed.

Growth of the continent.

The earliest land areas of the South American continent are approximately represented by the areas of old granites and gneisses. The largest of these is along the eastern border of the continent, reaching, with few interruptions, from a short distance south of the mouth of the Amazon river to the mouth of the Rio de la Plata. To the west of this land area there were probably many islands over what is now the interior of the continent. North of the present Amazon valley there was another and smaller land area or islands, where are now the highlands of North-eastern Brazil, South-eastern Venezuela, and Guiana. Another land area, or perhaps more correctly a string of islands, extended from the Falkland Islands the entire length of the west side of the continent. Against these shores the Cambrian or oldest sediments of the continent were laid down.

At the close of Cambrian times elevations of the continent added large tracts to the land, but the Silurian seas still covered what is now the Paraguayan basin, and extended from the Serra do Mar on the Brazilian coast to the axis of the Andes, on the Pacific side of the continent. During the Devonian period the land area of the continent was greatly increased in the Brazilian highlands, but the Devonian seas still covered the interior of the continent, extending from the Serra do Mar on the east to the Andes of Bolivia and Peru on the west, and forming a mediterranean sea over two hundred miles wide and several hundred miles long in the Lower Amazon valley region. In Carboniferous times the Amazonian inland sea was only slightly changed, but in the southern part of the continent the land areas increased enormously. In Southern Brazil there were peat bogs, while farther north and west were shallow brackish water bays or estuaries.

But little is known of the Triassic and Jurassic history of the continent.

The Cretaceous history of the east coast is preserved in only a few fragments of sedimentary areas. About the mouth of Rio São Francisco the land sank, carrying beneath the water large portions of the states of Sergipe and Alagôas. What are now the highlands of the interior of Piauhý, Ceará, Pernambuco, and Parahyba were then under water. The island of Trinidad was two-thirds under water at that time. On the west coast the land was lower than at present, and the ocean washed the base of the Andes at many places. Here and there, however, along that coast were great peat marshes extending from Peru as far south as the Strait of Magellan. The sea rovered what are now the plains of Patagonia and Argentina, and there was a wide bay between the low Andes ridges on the west and the Uruguayan peninsula on the east.

In the early part of Tertiary times the land sank somewhat, but the geography of much of the eastern coast was not greatly different from its present form. From Santa Catharina to Victoria on the coast of Brazil the shore was very nearly where it now is. From Victoria to Cape St Roque the shore line was from a few miles to a hundred miles farther inland than it is at present. Much of the coast belt, however, was covered by freshwater lakes, and in the Amazon valley region it is possible that these lakes, or some combination of lakes and estuaries, extended far up the valley.

In Tertiary times, probably at the end of the Eocene, great changes took place in the geography of South America. The entire continent rose to an elevation much greater than that at which it now stands. The coast lines were carried oceanward on all sides, so that the continent was enormously larger than it is at present. The coast line was 200 miles to the east of the Abrolhos Islands, which were then a part of the mainland, and 300 miles east of Victoria, Brazil. The Falkland Islands were also a part of the continent, and it is even probable that South America joined New Zealand and Australia through the antarctic regions. Denudation was very active during this period, and enormous quantities of the Eocene sediments were removed from the land. Towards the close of Tertiary times the continent sank again until the sea entered the Orinoco and Amazon valleys and made an island or group of islands of the highlands between Brazil, Venezuela, and the Guianas. During this period the valleys of Magdalena and Cauca and of Lake Maracaibo were covered by great bays. Still later a slight elevation added to the continental land area the lower portions of the Orinoco, Amazon, and La Plata valleys. During the Tertiary period volcanic activity culminated on the continent. The Andes rose, partly by continental uplifting, partly by faulting and folding, and partly by an upbuilding by the volcanic ejectamenta, from a series of comparatively low ridges to be the great mountain chain of the world. Volcanic activity, which had previously characterized the west coast region, increased enormously, lava sheets were poured out along the entire length of the continent, and enormous lava and cinder cones were built up about the craters. This volcanism was not confined to the Andes, but extended to the Patagonian plains, the highlands of the Paraná basin, the Abrolhos Islands, and as far east as the island of Fernando de Noronha. In recent times volcanic activity has entirely ceased along the eastern and north-eastern parts of the continent, and it has also subsided greatly, though it has not ceased altogether, along the west coast. The earthquakes that still disturb the west and north-west coast of the continent are more or less the result of this diminished volcanic action.

During Pleistocene times the southern end of the continent as far north as latitude 27° on the west coast was covered with glaciers moving away from the mountain ranges. North of 27° the glaciers did not flow down as far as the present sea-level, but they moved farther down the slopes of the higher portions of the Andes than they do at present. During a portion of the Glacial epoch the southern end of the continent stood at a somewhat lower elevation than at present, and the sea covered the plains of Patagonia and La Plata. On the east coast evidences of glaciation do not extend as far north as they do on the west coast.

Physical geography.

The South American continent rises abruptly from the ocean's floor along nearly all its coast line, but the abruptness of the continental margin is more marked on the western than on the eastern side. Contours of equal depth along the west coast show that from Valparaiso to the Isthmus of Panama, a distance of 3000 miles, the great Andes ranges are but the upper or subaerial portions of mountains rising from bases that lie 10,000 feet below the surface of the Pacific Ocean. South of Valparaiso the 10,000-feet contour moves far off the coast, but opposite the Strait of Magellan it approaches again within a distance of 150 miles. East of Patagonia the 1000-feet contour is so far from the coast that it passes to the east of the Falkland Islands, showing that this group stands upon a submerged continental shelf. From the mouth of the Rio de la Plata northward the 1000-feet submarine contour keeps at a distance of from 50 to 150 miles off the shore, nearly to Bahia, Brazil; from Bahia northward clear around Cape St Roque this line is close to the shore, and the ocean's bottom is steep, dropping abruptly to a depth of 5000 feet. The land relief of the continent of South America is characterized by—(1) the great range of lofty mountains which, with its narrow coast plain, follows its west coast from its northern to its southern extremity; (2) comparatively low and flat plains that slope eastward and southward from the base of these mountains down the drainage basins of the Orinoco, the Amazon, and the Paraguay; (3) the high table-lands of Eastern Brazil. The physical features of the west coast are bold. South of latitude 41°, the coast is characterized by a vast system of fjords and islands, probably produced by the recent submergence of a region of bold mountains and steep-sided valleys. The many islands, including Chiloe, Wellington, and Tierra del Fuego, are the higher portions that have remained above water; while the Strait of Magellan (properly Magalhães), Smyth Channel, and the other deep fjords that indent this coast line are the submerged valleys. The scenery in Smyth Channel is remarkably fine; the snow-clad mountains are visible on the east, while here and there glaciers flow down nearly or quite to the sea. Some of the islands are steep-sided peaks, mostly barren and uninhabited, and, in some cases, reaching an elevation of 4000 feet. The Strait of Magellan is 400 miles long, from 4 to 20 miles wide, and very deep. North of latitude 41° the coast is but little indented, and there are but few good ports. From Cape Horn, where the southern submerged end of the Andes forms the islands of Tierra del Fuego, to the Isthmus of Panama, the great Cordillera range follows the coast line closely, and at an even distance from it. The belt between the ocean and the mountains has an average width of about 40 miles, and on rare occasions, when the weather is favourable, the mountains are visible from the sea nearly all the way from Panama to the Strait of Magellan. Along the northern part of the continent, from Panama to Guayaquil,

EASTERN BRAZIL.

the coastal belt is covered with tropical vegetation; but from Guayaquil southward to latitude 30° much of the coast is a sandy, arid, and barren alkali desert. This arid belt is crossed here and there by streams flowing down from the high mountains, and along these streams are fertile valleys. Many of the streams, however, do not reach the sea, but dry up on their way across the coastal plain.

The Cordillera.

The great mountain chain is neither a single continuous sharp range nor a pair of ranges, but a broad ridge upon which rise many great isolated peaks. Towards its northern end, however, this great range divides —one branch, the Western Cordillera, continuing northward along and near the coast; another, the Merida, swinging away to the east, and, after certain breaks, ending east of Caracas in Venezuela, or, more properly, on the northern side of the island of Trinidad; while a third branch, the Sierra de Perija, runs northward between the valley of the Magdalena and Lake Maracaibo. On its west side the main Cordilleran ridge is scored by narrow steep-sided valleys, while on its eastern slope the average grade is more gentle and the valleys are less precipitous. Upon the Cordilleran ridge rise many of the highest mountain peaks in the world. The following are some of the highest and most noted of these peaks:—

PEAKS OF THE ANDES.

Peak.	Elevation.	Snow-line (approximate).
Aconcagua, Argentina . .	23,080	17,500
Mercedario, Argentina .	22,315	...
Tupungato, Argentina .	21,550	...
Illampu (Sorata), Bolivia .	21,500	...
Illimani, Bolivia . .	21,030	...
Sajama, Bolivia . .	21,028	..
Chimborazo, Ecuador . .	20,545	16,700
Juncal, Chili . . .	20,180	...
San Jose, Chili . .	20,020	...
Cotopaxi, Ecuador . .	19,613	15,500
Antisana, Ecuador . .	19,335	16,000
Cayambé, Ecuador . .	19,186	15,000
Tacora, Bolivia . .	19,000	...
Tolima, Colombia . .	18,300	...
Misti, Peru . . .	17,934	...
Altar, Ecuador . .	17,730	14,000
Maipó, Argentina . .	17,670	...
Sangai, Ecuador . .	17,464	...
Illiniza . . .	17,405	...
Torlola, Argentina . .	17,350	...
Carihuairazo . . .	16,750	15,000
Tunguragua, Ecuador .	16,690	...
Sierra de Santa Marta, Colombia	16,640	...
Sincholagua . . .	16,365	15,300
Cotocachi, Ecuador . .	16,301	14,500
Pichincha, Ecuador . .	15,918	...
Sara-urca . . .	15,502	14,000

There are several other peaks whose elevations exceed some of those given, but they have never been measured. The elevation of the snow-line upon these mountains varies somewhat, but it is lower on the east than on the west side. Of these peaks Cotopaxi, Tunguragua, Maipó, and Sangai are the largest active volcanoes in the world.

There are glaciers in the Andes immediately beneath the equator. The largest of these are upon Antisana, Cayambé, and Chimborazo, Altar, Carihuairazo, Cotocachi, Illiniza, Sara-urca, and Sincholagua (Whymper). Farther south in Chile and Argentina there are glaciers upon Aconcagua, Tupungato, &c., while in Patagonia along Smyth Channel and in the Strait of Magellan they are very large and flow down to the sea. The high Andes regions, even far below the lofty peaks, are cold, bare of vegetation, monotonous, and desolate. At a very few places there are cities and towns in the high mountains; Quito in Ecuador has an elevation of 9343 feet, Bogotá in Colombia of 8665 feet, while La Paz in Bolivia is 12,000 feet above the sea. The highest habitable portion generally has an elevation of about 8000 feet. But for the most part the lofty regions are unpeopled, so much so that this belt is known as the *Despoplado* or the unpeopled country. The high barren belt is comparatively narrow in Peru, but it widens southward through Bolivia, Chile, and Argentina. It has an average width of about 150 miles. (For further details see ANDES.)

The mountainous character of the western side of the continent ends abruptly in the Strait of Magellan. Northward along the east side of the continent the coast is flat as far as the northern part of Rio Grande do Sul. From latitude 33° 30′ to latitude 29° 30′ the coast is bordered by large brackish lakes. At latitude 29° 30′ the coast mountains of Brazil (the Serra do Mar) are near the ocean and follow the shore northward as far as latitude 19° 30′. This piece from 29° 30′ to 19° 30′ is the most picturesque portion of the Brazilian coast. The mountains rise in many places directly from the seashore to an elevation of more than 2000 feet. Where their sides are not smooth bare granite, they are covered with luxuriant tropical vegetation from base to summit. The port of Rio de Janeiro, one of the most beautiful in the world, and the ports of Santos and Victoria as well, are formed by a late depression of the coast that admitted the sea to narrow submerged valleys that had been cut by denudation on the margins of granite mountains. From latitude 20° northward the mountains swing inland, and the coast is low as far as Prado, latitude 17° 25′. North of Prado the coast is bordered by a wall of brightly coloured bluffs from 50 to 250 feet high, which continue with interruptions almost to the mouth of the Amazon. About Cape St Roque the coast is covered with sand dunes. From the Abrolhos Islands (lat. 18°) northward to Cape St Roque there are many coral reefs. In some places these reefs are several miles off shore, as they are near the Abrolhos, and many miles in length and breadth; in other places they follow the coast line for a hundred miles or more with few interruptions, now touching the shore and now standing out two or three miles from land. Occasionally there are small ports behind them. The most considerable break in their continuity is between the Bay of Bahia and the mouth of the Rio São Francisco. Along this same coast are reefs of hard sandstone that are often mistaken for coral reefs. These stone reefs stand like artificial walls or breakwaters across the mouths of the smaller rivers and the choked-up valleys, and thus form several of the ports on this part of the coast; such are Pernambuco, Natal, Porto Seguro, and several others of minor importance.

The Serra do Mar, or Brazilian coast range, is the most prominent topographic feature of the eastern side of the continent. This range, or group of ranges, backed by a high plateau, is within sight of the ocean from the north-eastern corner of Rio Grande do Sul in Brazil (lat. 29° 30′) to the mouth of Rio Doce, in S. latitude 19° 30′. The following are the highest points that have been measured on the Brazilian highlands:—

Peak.	Elevation.	
Itatiaya, State of Rio de Janeiro . .	9840	feet
Itajubá or Tembé, State of São Paulo .	7800 ±	,,
Organ Mountains, State of Rio de Janeiro .	7323	,,
Frade, State of Espirito Santo . . .	6770	,,
Caraça, State of Minas Geraes . . .	6234 ±	,,
Itambé, State of Minas Geraes . . .	5900 ±	,,
Itacolomi, State of Minas Geraes . .	5748	,,
Morro do Lopo, State of São Paulo . .	5250	,,
Serra da Onça, State of Rio de Janeiro . .	4592	,,
Pyreneos, State of Goyaz . . .	4544	,,

There is an elevated region near the eastern corner of the continent on the watershed between Rio São Francisco, Rio Jaguaribe, and Rio Parahyba do Norte. This watershed is not a mountain range, but a broad and broken plateau with an elevation of about 3000 feet, and with individual peaks reaching 4000 feet above tide level.

North of the mouth of the Amazon the coast is low, much of it is swampy, and all of it is forest-covered as seen from the ocean. This low coast extends across the Guianas and Venezuela as far as the headland north of the Gulf of Paria, where the Merida or Venezuelan branch of the Andes reaches the sea. Along this Guiana coast is a belt of low wooded land, beyond which the streams are not navigable save by canoes. The highlands south of Venezuela and the Guianas, and north of the Amazon valley, form a broad plateau, above which rise several high peaks. The known peaks are:—

Roraima . . .	8740 feet.
Duida . . .	8500 ,,
Maraguaca	8230 ,,
Turagua . . .	6000 ,,

This highland is mostly forest-covered, but there are in the area also large campos or open grass-covered plains.

Rivers.

The Amazon, the Orinoco, and the Paraguay or La Plata river systems drain an area of 3,686,400 square miles. Less imposing, but yet large and important streams are the Magdalena in Colombia, the Essequibo in British Guiana, and the São Francisco in Brazil. The Amazon (properly the Rio das Amazonas or river of the Amazons) and its tributaries is not only the largest river in South America, but by far the largest in the world (*q.v.*) The total navigable length of the main stream, from Pará to the head of the navigation on the Huallaga in Peru, is 3000 miles. This does not include the hundreds of equally navigable parallel side channels that accompany the main stream from its mouth almost to the mouth of the Javary. Above the falls, again, all these streams are navigable for long distances. The river is nowhere confined to a single channel, but its waters spread over an enormous flood-plain and flow with a sluggish current through thousands of side channels that anastomose with each other so that it is impossible for one not familiar with the stream to distinguish the main channel. In several places the river is so wide that one looking across it sees a water horizon as if he were looking out over the ocean. Indeed much of the region is more like a great freshwater sea filled with islands than it is like a valley with a stream running through it. For the most part the land along the river is low, flat, and marshy, and under water a part of the time; but at a few places, notably at Ereré, Obidos, Velha Pobre, Parú Parauá-quára, and Almeirim table-topped hills are visible from the river. The banks of the stream and of its side channels are everywhere lined with a dense forest. The valley, however, is not all forest-covered. Beginning near the Oyapok on the Guiana frontier, a series of dry sandy campos or open grassy plains, interrupted by wooded river banks, follow along the north side of the river for about 700 miles. The Upper Amazon valley opens broadly towards the north-east and descends to the sea through the Orinoco, while towards the south the Madeira basin, through one of its upper branches—the Guaporé—unites with the basin of the Paraguay.

The Orinoco proper (*q.v.*) rises in the highlands between Brazil and Venezuela, by a broad curve swings around the western end of these highlands, and then for 400 miles flows east into the Atlantic. Along its lower course the banks are covered with heavy forests. In its upper course the mountainous highlands are visible along its right bank, while on its left are enormous stretches of flat, treeless, grass-covered plains, extending to the foot-hills of the Cordillera de Merida. During high water, the low, flat country looks like a vast lake. The stream is navigable during a part of the year a distance of 1000 miles or more. Unlike the Amazon, the Orinoco has a great delta, and the stream enters the sea through many channels.

Under the name of the Rio de la Plata (*q.v.*) may be included the Uruguay, the Paraná, and the Paraguay, with all their tributaries. The plains of Argentina begin on the Amazonian watershed in the highlands of Matto Grosso, Brazil, and in Eastern Bolivia, and following down the valley of the Paraguay pass out of the drainage area of the Paraná, properly speaking, and form the flat region lying between the foot-hills of the Andes and the Atlantic Ocean almost to the Strait of Magellan—a length for this plain of more than 2000 miles. The plains in the latitude of Buenos Ayres and from there southward are low, nearly flat on the east side, and rise almost imperceptibly to the lower slopes of the Andes. They are mostly treeless deserts covered with tufts of coarse grass, with here and there shallow pools of salt or brackish water. There are many small volcanic peaks and some short mountain ranges over this great plain.

The valley of the Paraguay is here and there heavily timbered, in other places it is a treeless or sparsely-covered grassy plain, and in still others it is a hilly, dry, and thinly-covered campo. The upper Paraguay river winds through grass-covered, meadow-like plains apparently as flat and boundless as the sea. Above this plain rise a few isolated peaks, like so many islands in a great lake. Only above the navigable portions of the stream, 1700 miles from its mouth, does it flow through a hilly country. A noteworthy feature of the tributaries of the Paraguay is that many of those flowing down from the region of the Andes are more or less brackish, while the Uruguay and Paraná and their tributaries entering from the rainy, forest-covered regions of Brazil, are all freshwater streams.

The São Francisco is the largest river that lies wholly in Brazil. It rises in the highlands not far from the coast in latitude 21° and flows north-east parallel with the coast until it reaches latitude 9° 30′, where it bends sharply to the right and enters the Atlantic 360 miles south of Cape St Roque. It is navigable in its lower course, but at a distance of 140 miles from its mouth the falls of Paulo Affonso, the "Niagara of Brazil," interrupt all navigation. The upper part of the river, however, is navigable for a long distance. Throughout its entire length it flows through a hilly or mountainous country.

The Rio Magdalena in Colombia is a crooked, muddy stream entering the sea through two mouths; it is navigable up to Honda (862 feet above tide-level) and has a length of 2000 miles. Above the mouth of Rio Cauca, the mountains are visible on both sides of the river.

Lakes.

There are remarkably few freshwater lakes in South America, and most of these are in the Andes mountains. Lake Titicaca, near La Paz in Bolivia, is, in respect of elevation and position, the most remarkable lake of its size in the world. Its surface has an elevation of 12,545 feet, it covers an area of between 4000 and 5000 square miles, has a maximum depth of 700 feet, and never freezes over. Titicaca discharges into another shallow lake or marsh which is supposed to have no outlet. Lake Junin or Chinchaicocha on the plateau east of Lima in Peru has an area of 200 square miles, and an altitude of 13,380 feet. Along the eastern base of the Andes, in Southern Argentina, is a series of lakes whose basins were probably formed by the glaciers that formerly flowed down to the plains from the mountain ranges. There are many lakes over the flood-plains of all the great rivers of South America, but these are phases of the rivers themselves rather than lakes in the ordinary sense. Lagoa dos Patos and Lagoa Merim on the southern coast of Brazil are shallow brackish lakes shut in by sandbanks thrown up by the sea. There are small lagoons, formed in a similar manner, at many places along the coast in the states of Rio de Janeiro, Espirito Santo, and Alagôas. Lake Maracaibo on the Venezuela coast is a narrow-necked bay rather than a lake.

Islands.

The eastern coast of the South American continent has remarkably few islands, and these are all small, except Trinidad, off the coast of Venezuela, and the islands in the mouth of the river Amazon. The island of Trinidad (area, 1755 square miles) is separated from the continent by the Gulf of Paria. Along the northern end of the island is a range of mountains about 3000 feet high, which are geologically the eastern end of the Cumana range of the Venezuela mainland, with which they were formerly united. On the south side of the island is the famous pitch lake—the most extensive deposit of asphalt known. The island of Fernando de Noronha, 230 miles off Cape St Roque, is of volcanic origin, and has an area of 12 square miles. Although this island is separated from the mainland by a channel 13,000 feet deep, it really stands on the deep continental shelf. The Rocas, a small coral island, lies 80 miles west of Fernando de Noronha. The shores of the Falkland Islands (area, 6500 square miles) are indented by long tortuous channels that have the appearance of having been formed by the depression of a hilly land surface. One of these channels quite separates the two main islands. One peak, Mount Adams, has an elevation of 2300 feet. The group is separated from the mainland by a shallow sea, while its flora and fauna show that it was formerly connected with the Patagonian mainland. The Tierra del Fuego group of islands and the other islands that border the south-west coast, from the Strait of Magellan to latitude 42°, by their flora, fauna, the land forms and the forms and depths of the channels about them, show that they were not long ago, geologically speaking, a part of the mainland, from which they have become separated by the depression of the southern portion of the continent. This depression has admitted the sea to the lower valleys, making fjords of them, while the highlands and mountain tops remain projecting from the water as islands.[1]

Flora.

The flora of South America embraces a large number of peculiar types originating either in the highlands of Brazil or in the Andes region. Several of our most useful plants are natives of the South American tropics. Among these are the rubber-producing plants, cotton, potatoes, maize, the cinchona, Paraguayan tea, ipecac, vegetable ivory, coca, and the chocolate plant. Other tropical and subtropical plants, such as coffee, sugar-cane, oranges, and bananas have been introduced, and are extensively cultivated. The flora of the Amazon valley may be taken as the type of that of the moist valleys. The forests are almost impenetrable; roads through them are soon closed by the rank growth, and vines, creepers, and climbing plants turn them into veritable mats down to the water's edge. Bamboos reach an enormous size and form extensive thickets along certain streams. Palms are the most characteristic and beautiful trees, and reach their greatest development in the Amazon valley. They take on a great variety of forms: some have a height of 100 feet or more, others are no larger than a lead pencil and only a yard high; some are trunkless, while others are slender and climb like vines. A noteworthy feature of these tropical plants is that they seldom form forests of a single or of a few species, as so often occurs in the temperate zones. The shaded woods of the forests in many places abound in beautiful ferns, some of them reaching the dimensions of trees. The plants of the campos and plains have a stunted appearance. The grasses are wiry and tough, in places spreading evenly over thousands of square miles of nearly level marshy lands, as in the Gran Chaco of the Paraguay valley, in others growing in tufts over the sandy plains. In the high table-lands of Southern Brazil, the araucarian pine grows in beautiful forests as far north as Barbacena, state of Minas. In the north-west, the western slopes of the mountains are covered with a dense tropical vegetation high up their sides, while on the east they are comparatively bare. In the high mountains, the flora, though scant, resembles that of temperate regions. Sixty per cent. of the genera are like those of the temperate zones, but the species are peculiar to the Andes. On the lofty peaks Whymper collected, of flowering plants, fifty-nine species above 14,000 feet; thirty-five species above 15,000 feet; and twenty species above 16,000 feet.

Fauna.

The fauna of South America includes a large number of species, but relatively a small number of individuals. With local exceptions, this seems to be true of all the forms of life. The land mammals are nearly all small. There are many species of monkeys, all of them arboreal. The only reptiles that are at all abundant are lizards, and, in some places, alligators. There are only two large snakes, the boa constrictor and the water boa, and they are not abundant. The other kinds of snakes are represented by a small number of individuals. Certain ruminants having long woolly hair, the llamas, alpacas, and vicuñas, are found only in the high Andes. The llama has been domesticated, and is used for carrying small burdens. The condor, the largest living bird of flight, inhabits the lofty Andes. The insects of the highest peaks are related generically, but not specifically, to those of the temperate latitudes of North America, a fact interpreted by biologists to mean that, probably on account of some obstacles to free movement since the Glacial epoch, there has been no migration along the Andes during the existence of living species.

(J. C. Br.)

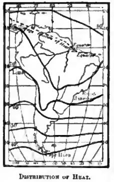
South American Meteorology.

Climate.

South America lies between the mean annual isotherms of 40° and 80° Fahr. The northern and north-eastern portions of the continent, down nearly to the tropic, are within the district enclosed by the mean annual isotherm of 80°. The cold Peruvian current deflects the isotherms strongly equatorwards along the Pacific coast, especially between latitudes 30° S. and the equator, while these same isotherms loop strongly polewards over the land. The equatorward deflexion on the west coast results in giving places on that coast much lower temperatures than those of stations in corresponding, or even considerably higher, latitudes on the east coast. Lima, in latitude 12° S., has a mean annual temperature of 66·2°; Rio de Janeiro, which is nearly on the tropic on the east coast, has a mean annual of 72·1°. The mean annual temperatures on the Atlantic coast between latitudes 30° and 40° S. are about 5° higher than those in corresponding latitudes on the Pacific coast. The average position of the heat equator (axis of the equatorial belt of high temperature) is on the immediate sea-coast in North-eastern Brazil, whence the line runs north-west parallel with, but somewhat inland from, the coast of Guiana and Venezuela. In January the heat equator moves to about 15° S. in Brazil, while in July it migrates northward beyond the limits of the continent. In the former month the isotherm of 50° crosses the southernmost extremity of South America. In July the isotherm of 30° is found somewhat to the south of Cape Horn. Thus the southern summer is not marked by excessively high mean temperatures, and the southern winter is moderate, even in the higher latitudes. The mean annual range of temperature is very small over all of South America. Over the northern portion of the continent, including Peru, Northern Bolivia, and the greater part of Brazil, it is less than 10°. Over a considerable part of this same area the range is even less than 5°. South of the tropic and east of the Andes the ranges increase to between 30° and 40° in Northern Argentina. In Chile, on the other hand, they are less than 20°. The whole of the narrow western coastal strip thus has a very moderate climate. Even in the higher latitudes the winters are very mild; the summers distinctly cool. Over a portion of the coasts of Guiana and of Eastern Venezuela the mean minimum temperatures average over 68°. The lowest mean minima are found in the interior east of the Andes and south of latitude 20° S. Temperatures below 32° occur normally every winter over the highlands of the southern interior of Brazil, and thence southward over the interior of Argentina. The highest mean maxima (104°) occur in the northern portion of Argentina. All of the west coast has decidedly lower maxima. Throughout the mountainous region of South America altitude controls temperature to a marked degree. Places situated far above sea-level (*e.g.*, Quito) enjoy "perpetual spring" temperatures. On the high peaks, even on the equator, there is eternal snow.

---

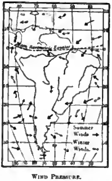
[1] The continent of South America has nearly all been explored after a fashion, but much of it has never been mapped. The statements frequently met with to the effect that there are large unexplored tracts should be taken with allowances. The various governments have concerned themselves but little with explorations and mapping, and whatever has been accomplished has been done incidentally rather than for the direct purpose of determining the geography and topography.



DISTRIBUTION OF HEAT.

Pressure and winds.

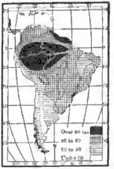
For the mean of the year the barometric equator crosses South America closely along the line of the geographical equator, running north of it on the western coast. The middle portion of the continent is under the control of the tropical high pressure belt, while over the southern extremity the pressure decreases rapidly towards the south pole. The seasonal migration of sun and heat equator involve a sympathetic migration of barometric equator and tropical high pressure belt. In January the barometric equator moves south to about lat. 10° in Brazil, while the axis of the tropical high pressure belt lies about along 30° S. lat. in the Atlantic, and 35° S. lat. in the Pacific. In July the barometric equator lies along the northern coast, and the axis of the tropical high pressure belt is also farther north than in January. Seasonal changes and mean monthly ranges of pressure are slight. The broad northern portion of the continent east of the Andes, and north of the tropical high pressure belt, is in the trade-wind zone. Here the trades prevail as a rule, except when the sun is most nearly overhead. They are then replaced by the equatorial belt of calms and rains, which migrates north and south over this portion of the continent, following the sun. The west coast within the trade-wind latitudes south of the equator has its own system of winds, which are under the control of the tropical high pressure area of the Pacific, and blow from a southerly direction. The winds of extra-tropical South America are also chiefly controlled by the tropical anti-cyclonic areas of the South Atlantic and South Pacific oceans. The former of these areas gives easterly and south-easterly winds in the lower latitudes of the eastern portion of the continent, and prevailing north-westerly winds in the higher latitudes. On the west coast strong southerly winds blow with trade-like regularity north of the Pacific anti-cyclone, while north-westerly winds prevail to the south of it. The seasonal migration of these areas of high pressure involves a corresponding shift in the wind systems under their control. In summer south and south-west winds prevail along the west coast between 30° and 40° S. lat. South of 40° S. lat. north and north-west winds predominate. In winter the winds between 30° and 40° S. lat. are variable, with some calms, while the west and north-west winds blow nearer the equator than in summer. In corresponding latitudes on the east coast there is also a northward extension of the limits of the north-west winds in winter. In Argentina north-east, east, and south-east winds increase in summer, and north, north-west, and west winds in winter. In the mountains there are local winds, much influenced by topography.



WIND PRESSURE.

Rainfall.

Darwin first distinctly emphasized the essential characteristics of South American rainfall. In the latitudes of prevailing easterly winds (trades) the eastern side of the continent and the eastern slopes of the Andes are well watered, while the western slopes are comparatively dry. In the latitudes of prevailing westerly winds the western slopes of the mountains have the most precipitation, while the eastern side is dry. The rainfall is considerable (60–80 inches and over) on the elevated windward coasts of the continent (Guiana, South-east Brazil) within the trade-wind belts, as it is on the eastern slopes of the Andes, and over an extended area along the Amazon. Within the south-east trade belt there is notably less rainfall in the lee of the highlands of South-east Brazil, and the rainfall also decreases rapidly in the interior over the more southern latitudes of this same belt. The migration of the belt of equatorial calms and rains over the northern portion of South America involves a seasonal rainfall over the greater part of the trade-wind latitudes. There is a dry season while the trade blows, and a rainy season while the equatorial rainy belt is overhead. The coast of Guiana, and Pernambuco and Bahia have winter rains. The west coast within the trade-wind latitudes, from 4° S. lat. to about 30° S., is very dry. It is shut off from the trades, and has southerly, cool, non-rainy winds. Along

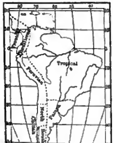


RAINFALL.

this desert coastal strip it seldom rains, but rain and snow fall on the mountains of Peru and Bolivia during the summer. North of lat. 4° S. there is abundant rainfall from the equatorial rainy belt, reaching 160 inches a year on the coast of Colombia north of the equator. Near the west coast the migration of the equatorial rain belt produces two rainy and two dry seasons at certain stations nearly on the equator (Quito and Bogotá). Within the latitudes of the prevailing westerly winds, the rainfall reaches 80 inches annually along the southern coast of Chile. East of the Andes, over much of the pampas of Argentina and Patagonia, the average is under 10 inches. Towards the southern extremity of the continent the rainfall east of the mountains increases again, reaching 40 inches a year in the extreme south-east. There is a seasonal distribution of rainfall in Chile which depends upon the migration of the tropical high pressure belt. Northern Chile, north of about 30° S. lat., is always dry. Southern Chile has rain throughout the year, because it is always under the régime of the prevailing westerly winds. In the central portion there are rains only in winter, when the westerlies impinge on that coast. Cyclonic storms do not occur north of the latitudes occupied by the prevailing westerly winds, but are very common in the high southern latitudes. The winter rains of Central Chile come in connexion with the cyclonic storms of that season. Thunderstorms are most frequent over the north-west coast, as far south as 4° S. lat., and occur in considerable numbers over all of tropical South America, except the arid west coast. The violent summer thunderstorms of Argentina and Uruguay (pamperos) often do serious damage to shipping in the Rio de la Plata estuary.

Climatic provinces.

South America may be divided into six climatic provinces (following Supan). The first ("Tropical Cordilleran") includes the extreme north-western section (coasts of Colombia and Ecuador), with "perpetual spring" climates at high altitudes, high temperatures near sea-level, and tropical rains. The second ("Tropical") takes in the vast northern and north-eastern territory east of the Andes, and reaches somewhat south of the tropics. This is under the control of trades and equatorial rains, and has mean annual temperatures over 80°. The third ("Peruvian") extends along the Pacific coast to 30° S. lat., including Northern Chile. This province is abnormally cool, and rainless. The "North Chilian" province, adjoining it on the south, has a subtropical climate, with winter rains. Farther south the "South Chilian" province, which takes in also the extreme southern extremity of the continent, is very rainy and has equable temperatures throughout the year, with cool summers The sixth ("Pampa") province, which includes the section east of the Andes and south of the tropical province, has a fairly large range of temperature, especially in the north, while rain is not plentiful.



CLIMATIC PROVINCES.

The following brief list includes some of the last notable additions to our knowledge of the geography of South America:—

HENRI A. COUDREAU. *Études sur les Guyanes et l'Amazonie.* Paris, 1886.—HENRI A. COUDREAU. *Voyages à travers les Guyanes et l'Amazonie.* Paris, 1887.—KARL VON DEN STEINEN. *Reiseschilderung und Ergebnisse der zweiter Schingú Expedition, 1887-1888.* Berlin, 1894.—EDWARD WHYMPER. *Travels amongst the Great Andes of the Equator.* London, 1892.—TEODORO WOLF. *Geografia y Geologia del Ecuador.* Leipzig, 1892.—E. A. FITZGERALD. *The Highest Andes.* London, 1899.—*A Topographic Survey of the State of São Paulo, Brazil, under the direction of* O. A. DERBY, H. E. WILLIAMS, *chief topographer.* In course of publication at São Paulo, Brazil.—*A Topographic Survey of the State of Minas Geraes, Brazil, under the direction of* ALVARO DA SILVEIRA. In course of publication at Bello Horizonte, Minas Gernes, Brazil.

See also for **Climate.**—HANN. *Handbuch der Klimatologie.* 2nd edition, Stuttgart, 1897. (The most complete discussion of South American climates. Gives numerous references.)—BARTHOLOMEW'S *Physical Atlas*, vol. iii. "Meteorology," London, 1899. (Charts of temperature, pressure, winds, rainfall, &c., with discussion.)

(R. DE C. W.)

AMERICAN ETHNOLOGY AND ARCHÆOLOGY.

The American aborigines.

The opinion is now well-nigh universal among anthropologists that the American aborigines came from the Old World. Whether with Payne it is assumed that in some remote time a speechless anthropoid passed over a land bridge, now the Bering Sea, which then sank behind him; or with Dawkins and Brinton, that the French cave man came hither by way of Iceland; or with Keane, that two subvarieties, the long-headed Eskimo-Botocudo type and the Mexican round-headed type, prior to all cultural developments, reached the New World, one by Iceland, the other by Bering Sea; or that Malayoid wanderers were stranded on the coast of South America; or that no breach of continuity has occurred since first the march of tribes began this way—ethnologists agree that the aborigines of the western came from the eastern hemisphere, and there is lacking any biological evidence of Caucasoid or Negroid blood flowing in the veins of Americans before the invasions of historic times. The time question is one of geology.

Following *Notes and Queries on Anthropology*, published by the British Association for the Advancement of Science, the study of the American aborigines divides itself into two parts: that relating to their biology, and that relating to their culture. In the four subdivisions of humanity based on the hair, the Americans are straight-haired or Mongoloid. But it will free this account of them from embarrassments if they be looked upon as a distinct subspecies of *Homo sapiens.* Occupying 135 degrees of latitude, living on the shores of frozen or of tropical waters; at altitudes varying from sea-level to several thousands of feet; in forests, grassy prairies, or deserts; here starved, there in plenty; with a night here of six months' duration, there twelve hours long; here among health-giving winds, and there cursed with malaria; this brown man became, in different culture provinces, brunette or black, tall or short, long-headed or short-headed, and developed on his own hemisphere variations from an average type.

Since the tribes practised far more in-breeding than out-breeding, the tendency was toward forming not only verbal linguistic groups, but biological varieties; the weaker the tribe, the fewer the captures, the greater the isolation, and harder the conditions—producing dolichocephaly, dwarfism, and other retrogressive characteristics. The student will find differences among anthropologists in the interpretation of these marks—some averring that comparative anatomy is worthless as a means of subdividing the American subspecies, others that biological variations point to different Old World origins, a third class believing these structural variations to be of the soil. The high cheek-bone and the hawk's-bill nose are universally distributed in the two Americas; so also are proportions between parts of the body, and the frequency of certain abnormalities of the skull, the hyoid bone, the humerus, and the tibia. Viability, by which are meant fecundity, longevity, and vigour, was low in average. The death-rate was high, through lack of proper weaning foods, and hard life. The readiness with which the American Indian succumbed to disease is well known. For these reasons there was not, outside of southern Mexico, northern Central America, and Peru, a dense population. In the whole hemisphere there were not over ten million souls.

The materials for studying the American man zoologically exist in the form of collections in Peabody Museum, Cambridge, Massachusetts, the Academy of Natural Sciences in Philadelphia, and the United States National Museum in Washington. Professor Putnam measured for the World's Columbian Exposition 17,000 living Indians, and the results have been summed up by Boas. The breadth of the Indian face is one centimetre more than that of the whites, and the half-breeds are nearer the Indian standard; this last is true also of colour in the skin, eyes, and hair. In stature, the tall tribes exceed 170 cm.; middle stature ranges between 166 and 170; and short tribes are under 166 cm. The Indians are on the whole a tall people. Tribes that have changed residence have changed stature. The tallest statures are on the plains. The mountains of the south-east and of the west reveal the shortest statures. The whole Mississippi Valley was occupied by tall peoples. The Athapascans of New Mexico are of middle stature, the Pueblo peoples are short. The Shoshone, Shahaptin, and Salish tribes are of middle stature; on the coast of British Columbia, Puget Sound, in Oregon, and Northern California, are the shortest of all the North Americans save the Eskimo, while among them, on the Columbia, are taller tribes. The comparison of cranial indexes is rendered difficult by intentional flattening of the forehead and undesigned flattening of the occiput by the hard cradle-board. The Mississippi Valley tribes are nearly brachycephalic; the index increases around the Great Lakes, and lessens farther east. The eastern Eskimo are dolichocephalic, the western are less so, and the Aleuts brachycephalic. On the North Pacific coast, and in spots down to the Rio Grande, are short heads, but scattered among these are long heads, frequent in Southern California, but seen northward to Oregon, as well as in Sonora and some Rio Grande pueblos. In the regions of greatest linguistic mixture is the greatest heterogeneity of cephalic index.

Classification.

The concepts on which the peoples of the Old World have been classified, such as stature, colour, skeletal measurements, nationality, and so on, cannot as yet be used in America with success. The only basis of division practicable is language, which must be kept separate in the mind from the others. However, before the conquest, in no other part of the globe did language tally so nearly with kinship. Marriage was exogamic among clans in a tribe, but practically, though not wholly, endogamic as between tribes, wife and slave capture being common in places. In his family tree of *Homo Americanus* Keane follows out such a plan, placing the chief linguistic family names on the main limbs, North American on one side, and South American on the other. Deniker groups mankind into twenty-nine races and sub-races. Americans are numbered thus:—21, South American sub-race; Palæo-Americans and South Americans. 22, North American sub-race; tall, mesocephalic. 23, Central American race; short, brachycephalic. 24, Patagonian race; tall, brachycephalic. 25, Eskimo race; short, dolichocephalic.

Culture provinces.

Zoologists divide the earth into biological areas or regions, so both archæologists and ethnologists may find it convenient to have in mind some such scheme of provinces as the following, named partly after the dominant ethnic groups:—Eskimo, on Arctic shores; Déné, in North-western Canada; Algonkin-Iroquois, Canada and Eastern United States; Sioux, plains of the west; Muskhogee, Gulf States; Tlinkit-Haida, North Pacific coast; Salish-Chinook, Fraser-Columbia coasts and basins; Shoshone, interior basin; California-Oregon, mixed tribes; Pueblo province, South-western United States and Northern Mexico; Nahuatla-Maya, Southern Mexico and Central America; Chibcha-Kechua, the Cordilleras of South America; Carib-Arawak, about Caribbean Sea; Tupi-Guarani, Amazon drainage; Araucanian, Pampas; Patagonian, peninsula; Fuegian, Magellan Strait. It is necessary to use geographical terms in the case of California and the North Pacific, the Caucasus or *cloaca gentium* of the western hemisphere, where were pocketed forty out of one hundred or more families of native tribes. The same is true in a limited sense of Matto Grosso. That these areas had deep significance for the native races is shown by the results, both in biology and culture. The presence or absence of useful minerals, plants, and animals rendered some congenial, others unfriendly; some areas were the patrons of virile occupations, others of feminine pursuits.

Language.

Among the languages of America great differences exist in the sounds used. A collection of all the phonetic elements exhausts the standard alphabets and calls for new letters. A comparison of one family with another shows also that some are vocalic and soft, others wide in the range of sounds, while a third set are harsh and guttural, the speaking of them (according to Payne) resembling coughing, barking, and sneezing. Powell also thinks that man lived in America before he acquired articulate speech. The utterance of these speech elements in definite order constitutes the roots and sentences of the various tongues. From the manner of assemblage, all American languages are agglutinative, or holophrastic, but they should not be called polysynthetic or incorporative or inflexional. They were more or less on the way to such organized forms, in which the world's literatures are preserved. As in all other languages, so in those of aboriginal America, the sentence is the unit. Words and phrases are the organic parts of the sentence, on which, therefore, the languages are classified. It is on this basis of sentential elements that Powell has arranged the linguistic families of North America. He has brought together, in the Bureau of Ethnology. in Washington, many hundreds of manuscripts, written by travellers, traders, missionaries, and scholars; and, better still, in response to circulars, carefully-prepared vocabularies, texts, and long native stories have been written out by trained collectors. A corps of specialists—Boas, Dorsey, Gatschet, Hewitt, Mooney, Pilling—have studied many of these languages analytically and comparatively. Other institutional investigations have been prosecuted, the result of all which will be an intelligent comprehension of the philology of a primitive race.

Linguistic families.

Attention is frequently called to the large number of linguistic families in America, nearly 200 having been named, embracing over 1000 languages and dialects. A few of them, however, occupied the greater part of the lands both north and south of Panama; the others were encysted in the territory of the prevailing families, or concealed in *culs-de-sac* of the mountains. They are, through poverty of material, unclassed languages, merely outstanding phenomena. Factions separated from the parent body developed dialects or languages by contact, intermarriage, and incorporation with foreign tribes. To the old-time belief that languages multiplied by splitting and colonizing, must be added the theory that languages were formerly more numerous, and that those of the Americans were formed by combining.

The families of North America, Middle America, and South America are here given in alphabetical order, the prevailing ones in small capitals:—

North America.

ALGONQUIAN, E. Can., N. Atlantic States, middle States, middle Western States; ATHAPASCAN, N.W. Can., Alaska, Wash., Or., Cal., Ariz., Mex.; Attacapan, La.; Beothukan, Nova Scotia; CADDOAN, Tex., Neb., Dak.; Chimakuan, Wash.; Chimarikan, N. Cal.; CHIMMESYAN, Brit. Col.; CHINOOKAN, Or.; Chitimachan, La.; Chumashan, S. Cal.; Coahniltecan, Tex.; Copehan, N. Cal.; Costanoan, Cal.; ESKIMAUAN, Arctic province; Esselenian, Cal.; IROQUOIAN, N.Y., N.C.; Kalapooian, Or.; Karankawan, Tex.; KERESAN, N. Mex.; KIOWAN, Neb.; KITUNAHAN, Brit. Col.; KOLUSCHAN, S. Alaska; KULANAPAN, Cal.; Kusan, Cal.; Lutuamian, Or.; Mariposan, Cal.; Moquelumnan, Cal.; MUSKHOGEAN, Gulf States; NATCHESAN, Miss.; Palaihnihan, Cal.; PIMAN, Ariz.; Pujunan, Cal.; Quoratean, Or.; Salinan, Cal.; SALISHAN, Brit. Col.; Sastean, Or.; SHAHAPTIAN, Or.; SHOSHONEAN, Interior Basin; SIOUAN, Mo. Valley; SKITTAGETAN, Brit. Col.; Takilman, Or.; TANVOAN, Mex.; Timuquanan, Fla.; Tonikan, Miss.; Tonkawan, Tex.; Uchean, Ga.; Waiilatpuan, Or.; WAKASHAN, Vancouver I.; Washoan, Nev.; Weitspekan, Or.; Wishoskan, Cal.; Yakonan, Or.; Yanan, Or.; Yukian, Cal.; Yuman, L. Cal.; ZUNYAN, N. Mex.

Middle America.

CHAPANECAN, Chi.; Chinantecan, Oax.; Chontalan, So. Mex.; Huatusan, Nic.; Lencan, Hon.; MAYAN, Yuc. and Guat.; NAHUATLAN, Mex.; OTOMITLAN, Cen. Mex.; Raman, Hond.; Subtiaban, Nic.; TARASCAN, Mich.; Tehuantepecan, Isthmus; Tequistlatecan, Oax.; TOTONACAN, Mex.; Triquian, So Mex.; Ulvan, Nic.; Xicaquean, Hond.; ZAPOTECAN, Oax.; ZOQUEAN, Tehuant.

South America.

Alikulufan, T. del Fuego; Arauan, R. Purús; ARAWAKIAN, E. Andes; Atacamenyan, S. Peru; ARAUCANIAN, Pampas; AYMARAN, Peru; Barbacoan, Colombia; Betoyan, Bogota; Canichanan, Bolivia; Carahan, S. Brazil; CARIBIAN, around Caribbean Sea; Catamarenyan, Chaco; Changuinan, Panama; Charruan, Paraná R.; CHIBCHAN, Colombia; Churoyan, Orinoco R.; Coconucan, Colombia; Cuuan, Panama; GUAYCURUAN, Paraguay R.; JIVAROAN, Ecuador; KECHUAN, Peru; Laman, N.E. Peru; Lulean, Vermejo R.; Mainan, S. Ecuador; Matacoan, Vermejo R.; Mocoan, Colombia; Mosetenan, E. Bolivia; ONAN, T. del Fuego; Paniquitan, Colombia; Panoan, Ucayali R., Peru; Puquinan, Titicaca L.; Samucan, Bolivia; Tacanan, N. Bolivia; TAPUYAN, Brazil; Timotean, Venezuela; TUPIAN, Amazon R.; TZONECAN, Patagonia; YAHGAN, T. del Fuego; Yuncan, Truxillo, Peru; Yarucarian, E. Bolivia; ZAPAROAN, Ecuador.

Written language was largely hierographic and heroic. The drama, the cult image, the pictograph, the synechdochic picture, the ideaglyph, were steps in a progress without a break. The warrior painted the story of conflicts on his robe only in part, to help him recount the history of his life; the Eskimo etched the prompters of his legend on ivory; the Tlinkit carved them on his totem post; the women fixed them in pottery, basketry, or blankets. At last, the central advanced tribes made the names of the abbreviated pictures useful in other connexions, and were far on the way to a syllabary. Intertribal communication was through gestures; it may be, survivals of a primordial speech, antedating the differentiated spoken languages.

Technology.

To supply their wants the Americans invented modifications in natural materials, the working of which was their industries. The vast collections in richly-endowed European and American museums are the witnesses and types of these. There is danger of confounding the products of native industries. The following classes must be carefully discriminated:—(*a*) pre-Columbian, (*b*) Columbian, (*c*) pre-contact, (*d*) first contact, (*e*) post-contact, (*f*) present, and (*g*) spurious. Pre-Columbian or pre-historic material is further classified into that which had been used by Indians before the discovery, and such as is claimed to be of a prior geological period. Columbian, or 15th-century material, still exists in museums of Europe and America, and good descriptions are to be found in the writings of contemporary historians. Pre-contact material is such as continued to exist in any tribe down to the time when they were touched by the presence of the trade of the whites. In some tribes this would bring the student very near to the present time; for example, before Steinen, the Indians in Matto Grosso were in the pre-contact period. Post-contact material is genuine Indian work more or less influenced by acculturation. It is interesting in this connexion to study also first contact in its lists of articles, and the effects produced upon aboriginal minds and methods. For example, a tribe that would jump at iron arrow-heads stoutly declined to modify the shafts. Present material is such as the Indian tribes of the two Americas are making to-day. Spurious material includes all that mass of objects made by whites and sold as of Indian manufacture; some of it follows native models and methods; the rest is fraudulent and pernicious. The question whether similarities in technology argue for contact of tribes, or whether they merely show corresponding stages of culture, with modifications produced by environment, divides ethnologists.

Aboriginal mechanics.

The study of mechanics involves materials, tools, processes, and products. No iron tools existed in America before the invasion of the whites. Mineral, vegetable, and animal substances, soft and hard, were wrought into the supply of wants by means of tools and apparatus of stone, wood, and bone; tools for cutting, or edged tools; tools for abrading and smoothing the surfaces of substances, like planes, rasps, and sandpaper; tools for striking, that is, pounding for the sake of pounding, or for crushing and fracturing violently; perforating tools; devices for grasping and holding firmly. These varied in the different culture provinces according to the natural supply, and the presence or absence of good tool material counted for as much as the presence or absence of good substances on which to work. As a means of grading progress among the various tribes, the tool is valuable both in its working part and its hafting, or manual part. Fire drills were universal.

Besides chipped stone knives, the teeth of rodents, sharks, and other animals served an excellent purpose. In North-west America and in the Caribbean area the adze was highly developed. In Mexico, Colombia, and Peru the cutting of friable stone with tough volcanic hammers and chisels, as well as rude metallurgy, obtained, but the evidences of smelting are not convincing. Engineering devices were almost wanting. The Eskimo lifted his weighted boat with sheer-legs made of two paddles; he also had a tackle without sheaves, formed by reaving a greased thong through slits cut in the hide of a walrus. The North-West Coast Indians hoisted the logs that formed the plates of their house frames into position with skids and parbuckles of rope. The architectural Mexicans, Central Americans, and especially the Peruvians, had no derricks or other hoisting devices, but rolled great stones into place along prepared ways and up inclined planes of earth, which were afterwards removed. In building the fortress of Sacsahuaman, heights had to be scaled; in Tiahuanaco stones weighing 400 tons were carried seventeen miles; in the edifices of Ollantaytambo not only were large stones hauled up an ascent, but were fitted perfectly. The moving of vast objects by their simple processes shows what great numbers of men could be enlisted in a single effort, and how high a grade of government it was which could hold them together and feed them. In Arizona, Mexico, and Peru reservoirs and aqueducts prove that hydrotechny was understood.

Time-keeping devices were not common. Sun-dials and calendar monuments were known among the more advanced tribes. Fractional portions of time were gauged by shadows, and time of day indicated by the position of the sun with reference to natural features. No standards of weighing or measuring were known, but the parts of the body were the units, and money consisted in rare and durable vegetable and animal substances, which scarcely reached the dignity of a mechanism of exchange. If the interpretation of the Maya calculiform glyphs be trustworthy, these people had carried their numeral system into the hundreds of thousands, and devised symbols for recording such high numbers.

Food.

The Americans were, in most places, flesh-eaters. The air, the waters, and the land were their base of supplies, and cannibalism, it is admitted, was widespread. With this animal diet everywhere, vegetable substances were mixed, even in the boreal regions. Where the temperature allowed vegetable diet increased, and fruits, seeds, and roots were laid under tribute. Storage was common, and also the drying of ripened fruits. The most favoured areas were those where corn and other plants could be artificially produced, and there barbaric cultures were elaborated. This farming was of the rudest kind. Plots of ground were burned over, trees were girdled, and seeds were planted by means of sharpened sticks. The first year the crop would be free from weeds, the second year only those grew whose seeds were wafted or carried by birds, the third year the crop required hoeing, which was done with sticks, and then the space was abandoned for new ground. Irrigation and terrace culture were practised at several points on the Pacific slope from Arizona to Peru. The steps along which plant and animal domestication passed upwards in artificiality are graphically illustrated in the aboriginal food quest.

Clothing and adornment.

Except in the boreal areas the breech-clout was nearly universal with men, and the cincture or short petticoat with women. Even in Mexican and Mayan sculptures the gods are arrayed in gorgeous breech-clouts. The foot-gear in the tropics was the sandal, and passing northward the moccasin, becoming the long boot in the Arctic. Trousers and the blouse were known only among the Eskimo, and it is difficult to say how much these have been modified by contact. Leggings and skin robes took their place southward, giving way at last to the nude. Head coverings also were gradually tabooed south of the 49th parallel. Tattooing and painting the body were well-nigh universal. Labrets were worn by Eskimo, Tlinkit, Nahuatlas, and tribes on the Brazilian coast. For ceremonial purposes all American tribes were expert in masquerade and dramatic apparel. A study of these in the historic tribes makes plain the motives in gorgeous Mexican sculptures.

Habitation.

The tribal system of family organization, universal in America, dominated the dwelling. The Eskimo underground houses of sod and snow, the Déné and Sioux bunch of bark or skin wigwams, the Pawnee earth lodge, the Iroquois long house, the Tlinkit great plank house, the Pueblo with its honeycomb of chambers, the small groups of thatched houses in tropical America, and the Patagonian toldos of skin are examples. The Indian habitation was made up of this composite abode, with whatever out-structures and garden plots were needed. A group of abodes, however joined together, constituted the village or home of the tribe, and there was added to these a town hall or large assembly structure where men gathered and gossiped, and where all dramatic and religious ceremonies were held. Powell contends that in a proper sense none of the Indian tribes were nomadic, but that governed by water-supply, bad seasons, and superstition (and discomfort from vermin must be added), even the Pueblo tribes often tore down and rebuilt their domiciles. The fur trade, the horse, the gun, disturbed the sedentary habit of American tribes. Little attention was paid to furniture. In the smoke-infested wigwam and hut the ground was the best place for sitting or sleeping. The communal houses of the Pacific coast had bunks. The hammock was universal in the Tropics, and chairs of wood or stone. Eating was from the pot, with the hand or spoon. Tables, knives, forks, and other prandial apparatus were as lacking as they were in the palaces of kings a few centuries before.

Stone-working.

Stone-working was universal in America. The tribes quarried by means of crowbars and picks of wood and bone. They split the silicious rocks with stone hammers, and then chipped them into shape with bone tools. Soap-stone for pottery was partly cut into the desired shape in the native ledge, broken or prised loose, and afterwards scraped into form. Paint was excavated with the ubiquitous digging-stick, and rubbed fine on stones with water or grease. For polished stonework the material was pecked by blows, ground with other stones, and smoothed with fine material. Sawing was done by means of sand or with a thin piece of harder stuff. Boring was effected with the sand-drill; the hardest rocks may have been pierced with specially hard sand. At any rate stones were sawed, shaped, polished, carved, and perforated, not only by the Mexicans, but among other tribes. For building purposes stones were got out, dressed, carved, and sculptured with stone hammers and chisels made of hard and tenacious rock. Stonecutters' tools of metal are not known to have existed, and they were not needed. Their quarrying and stone working was most wasteful. Those localities where chipping was done reveal hundreds of tons of splinters and failures, and these are often counted as ruder implements of an earlier time. The dressed stones for great buildings were pecked out of the ledges, and broken off with levers in pieces much too large for their needs.

Metallurgy.

Metals were treated as malleable stones by the American aborigines. No evidence of smelting ores with fluxes is offered, but casting from metal melted in open fires is assumed. Gold, silver, copper, pure or mixed with tin or silver, are to be found here and there in both continents, and nuggets were objects of worship. Tools and appliances for working metals were of the rudest kind, and if moulds for casting were employed these were broken up; at least no museum contains samples of them, and the processes are not described. In the Arctic and Pacific coast provinces, about Lake Superior, in Virginia and North Carolina, as well as in ruder parts of Mexico and South America, metals were cold-hammered into plates, weapons, rods, and wire, ground and polished, fashioned into carved blocks of hard, tenacious stone by pressure or blow, overlaid, cold-welded, and plated. Soldering, brazing, and the blowpipe in the Cordilleran provinces are suspected, but the evidence of their existence must be further examined. A deal of study has been devoted to the cunning Tubal Cains, the surprising productions of whose handiwork have been recovered in the art provinces of Mexico and the Cordilleras, especially in Chiriqui, between Costa Rica and Colombia. It must be admitted, however, that both the tools and the processes have escaped the archæologist, as they did "the ablest goldsmiths in Spain, for they never could conceive how they had been made, there being no sign of a hammer or an engraver or any other instrument used by them, the Indians having none such" (Herrera).

Pottery.

The potter's wheel did not exist in the Western world, but it was almost invented. Time and muscle, knack and touch, a trained eye and brain, and an unlimited array of patterns hanging on fancy's walls, aided by a box of dry sand, were competent to give the charming results. No more striking contrast can be found between forlorn conditions and refined art products. Art in clay was far from universal in the two Americas. The Eskimo on Bering Sea had learned to model shallow bowls for lamps. No pottery existed in Athapascan boundaries. Algonkin-Iroquois tribes made creditable ware in South-eastern Canada and eastern United States. Muskhogean tribes were potters, but Siouan tribes, as a rule, in all the Mississippi drainage were not. In their area, however, dwelt clay-working tribes, and the Mandans had the art. Moreover, the mound-builders in the eastern half of this vast plain, being sedentary, were excellent potters. In the Muskhogee province the tribes were more settled, making clay vessels possible. On the Pacific side of the continent not one of the forty linguistic families made pottery. The only workers in clay west of the Rockies and north of the Pueblo country belonged to the Shoshonean family in the interior basin.

Textile industries.

The study of Indian textiles includes an account of their fibres, tools, processes, products, ornaments, and uses. Their fibres were either animal or vegetable; animal fibres were hair, fur on the skin, feathers, hide, sinew, and intestines; vegetable fibres were stalks of small trees, brush, straw, cotton, bast, bark, leaves, and seed vessels in great variety as one passes from the north southward through all the culture provinces. The products of the textile industry in America were bark cloth, wattling for walls, fences and weirs, paper, basketry, matting, loom products, needle or point work, net-work, lace-work, and embroidery. In the manufacture of these the substances were reduced to the form of slender filaments, shreds, rods, splints, yarn, twine, and sennit or braid. All textile work was done by hand; the only devices known were the bark-peeler, the shredder, the flint-knife, the spindle, the rope-twister, the bodkin, the warp-beam, and the most primitive harness. The processes involved were gathering the raw material, shredding, splitting, gouging, wrapping, twining, spinning, and braiding. Twining and spinning were done with the fingers of both hands, with the palm on the thigh, with the spindle, and with the twister. Ornamentation was in form, colour, technical processes, and dyes. The uses to which the textiles were put were for clothing, furniture for the house, utensils for a thousand industries, fine arts, social functions, and worship.

In order to comprehend the more intricate processes of the higher peoples it is necessary to examine the textile industry in all of the culture areas. It is essentially woman's work. The Eskimo woman did not weave, but was expert in sewing and embroidering with sinew thread by means of a bodkin. The Déné peoples used strips of hide for snowshoes and game-bags, sewed their deerskin clothing with sinew thread, and embroidered in split quill. Their basketry, both in Canada and in Arizona, was coiled work. The northern Algonkin and Iroquoian tribes practised similar arts, and in the Atlantic States wove robes of animal and bird skins by cutting the latter into long strips, winding these strips on twine of hemp, and weaving them by the same processes employed in their wicker basketry. Textile work in the Sioux province was chiefly the making of skin garments with sinew thread, but in the Gulf States the existence of excellent cane and grasses gave opportunity for several varieties of weaving. On the Pacific coast of America the efflorescence of basketry in every form of technic was known. This art reached down to the borders of Mexico. Loom-weaving in its simplest form began with the Chilkats of Alaska, who hung the warp over a long pole, and wrought mythological figures into their gorgeous blankets by a process resembling tapestry work. The forming of bird skins, rabbit skins, and feathers into robes, and all basketry stitches, existed from Vancouver Island to Central America. In northern Mexico net-work, rude lace-work in twine, are followed farther south, where finer material existed, by figured weaving of most intricate type and pattern; warps were crossed and wrapped, wefts were omitted, and texture changed, so as to produce marvellous effects upon the surface. This composite art reached its climax in Peru, the llama wool affording the finest staple on the whole hemisphere. Textile work in other parts of South America did not differ from that of the Southern States of the Union. The addition of brilliant ornamentation in shell, teeth, feathers, wings of insects, and dyed fibres completed the round of the textile art. A peculiar type of coiled basketry is found at the Strait of Magellan, but the motives are not American.

Zootechny.

Since most American tribes lived upon flesh, the activities of life were associated with the animal world. These activities were not confined to the land, but had to do also with those littoral meadows where invertebrate and vertebrate marine animals fed in unlimited numbers. An account of savage life, therefore, includes the knowledge of the animal life of America and its distribution, regarding the continent, not only as a whole, but in those natural history provinces and migrations which governed and characterized the activities of the peoples. This study would include industries connected with capture, those that worked up into products the results of capture, the social organizations and labours which were involved in pursuit of animals, the language, skill, inventions, and knowledge resulting therefrom, and, finally, the religious conception united with the animal world, which has been named zootheism. In the capture of animals would be involved the pedagogic influence of animal life; the engineering embraced in taking them in large numbers; the cunning and strategy necessary to hunters so poorly armed giving rise to disguises and lures of many kinds. Capture begins among the lower tribes with the hand, without devices, developing knack and skill in seizing, pursuing, climbing, swimming, and maiming without weapons; and proceeds to gathering with devices that take the place of the hand in dipping, digging, hooking, and grasping; weapons for striking, whether clubs, missiles, or projectiles; edged weapons of capture, which were rare in America; piercing devices for capture, in lances, barbed spears, harpoons, and arrows; traps for enclosing, arresting, and killing, such as pens, cages, pits, pen-falls, nets, hooks, nooses, clutches, adhesives, deadfalls, impalers, knife traps, and poisons; animals consciously and unconsciously aiding in capture; fire in the form of torches, beacons, burning out and smoking out; poisons and asphyxiators; the accessories to hunting, including such changes in food, dress, shelter, travelling, packing, mechanical tools, and intellectual apparatus as demanded by these arts. Finally, in this connexion, the first steps in domestication, beginning with the improvement of natural corrals or spawning grounds, and hunting with trained dogs and animals. Zootechnic products include food, clothing, ornaments, habitations, weapons, industrial tools, textiles, money, &c.

In sociology the dependence of the American tribes upon the animal world becomes most apparent. A great majority of all the family names in America were from animal totems. The division of labour among the sexes was based on zootechny. Labour organizations for hunting, communal hunt, and migrations had to do with the animal world.

In the duel between the hunter and the beast-mind the intellectual powers of perception, memory, reason, and will were developed; experience and knowledge by experience were enlarged, language and the graphic arts were fostered, the inventive faculty was evoked and developed, and primitive science was fostered in the unfolding of numbers, metrics, clocks, astronomy, history, and the philosophy of causation. Beliefs and practices with reference to the heavenly world were inspired by zoic activities; its location, scenery, and environment were the homes of beast gods. It was largely a zoopantheon; thus zootheism influenced the organization of tribes and societies in the tribes. The place, furniture, liturgies, and apparatus of worship were hereby suggested. Myths, folk-lore, hunting charms, fetishes, superstitions, and customs were based on the same idea.

Travel. Excepting for extensive and rapid travel over the snow in the Arctic regions by means of dog sleds, the extremely limited transportation by dog travail (or sledge) in the Sioux province, and the use of the llama as a beast of burden throughout the Peruvian highlands, land travel was on foot, and land transportation on the backs of men and women. One of the most interesting topics of study is the trails along which the seasonal and annual migrations of tribes occurred, becoming in Peru the paved road, with suspension bridges and wayside inns or tambos. In Mexico, and in Peru especially, the human back was utilized to its utmost extent, and in most parts of America harness adapted for carrying was made and frequently decorated with the best art. In the Mexican codices pictures of men and women carrying are plentiful. Travelling on the water was an important activity in aboriginal times. Hundreds of thousands of miles of inland waters and archipelagoes were traversed. Commencing in the Arctic region, the Eskimo in his kayak, consisting of a framework of drift wood or bone covered with dressed sealskin, could paddle down East Greenland, up the west shore to Smith Sound, along Baffin Land and Labrador, and the shores of Hudson Bay throughout insular Canada and the Alaskan coast, around to Mount St Elias, and for many miles on the eastern shore of Asia. In addition to this most delicate and rapid craft, he had his umiak or freight boat, sometimes called woman's boat. The Athapascan covered all North-western Canada with his open birch-bark canoe, somewhat resembling the kayak in finish. The Algonkin-Iroquois took up the journey at Bear Lake and its tributaries, and by means of paddling and portages traversed the area of Middle and Eastern Canada, including the entire St. Lawrence drainage. The absence of good bark, dugout timber, and chisels of stone, deprived the whole Mississippi Valley of creditable watercraft, and reduced the natives to the clumsy trough for a dugout and miserable bull-boat, made by stretching dressed buffalo hide over a crate. On the Atlantic coast of the United States the dugout was improved in form where the waters were more disturbed. John Smith's Indians had a fleet of dugouts. The same may be said of the Gulf States tribes, although they added rafts made of reed. Along the archipelagoes of the North Pacific coast, from Mount St Elias to the Columbia river, the dugout attained its best. The Columbia river canoe resembled that of the Amur, the bow and stern being pointed at the water line. Poor dugouts and rafts, made by tying reeds together, constituted the watercraft of California and Mexico until Central America is reached.

The Caribs were the Haidas of the Caribbean Sea and Northern South America. Their craft would vie in form, in size, and seaworthiness with those of the North Pacific coast. The catamaran and the reed boat were known to the Peruvians. The tribes of Venezuela and Guiana, according to Im Thurn, had both the dugout and the built-up hull. The simplest form of navigation in Brazil was the woodskin, a piece of bark stripped from a tree, and crimped at the ends. The sangada, with its platform and sail, belonging to the Brazilian coast, is spoken of as a good seaworthy craft. Finally, the Fuegian bark canoe, made in three pieces so that it can be taken apart and transported over hills and sewed together, ends the series. The American craft was propelled by poling, paddling, and by rude sails of matting.

Fine art. The æsthetic arts of the American aborigines cannot be studied apart from their languages, industries, social organizations, lore, and worships. Art was limited most of all by poverty in technical appliances. There were just as good materials and inspirations, but what could the best of them do without metal tools? One and all, skilful to a surprising degree—weavers, embroiderers, potters, painters, engravers, carvers, sculptors, and jewellers—they were wearied by drudgery and overpowered by a never-absent, weird, and grotesque theology. The Eskimo engraved poorly, the Déné embroidered, the North Pacific tribes carved skilfully in horn, slate, and cedar, the California tribes had nimble fingers for basketry, the Sioux, like the Mexicans, gloried in feathers. The mound builders, Pueblo tribes, middle Americans, and Peruvians, were potters of many schools, gorgeous colour fascinated the Amazonians, the Patagonians delighted in skins, and even the Fuegians saw beauty in the pretty snail shells of their desolate island shores. Of the Mexican and Central American sculpture and architecture a competent judge says that Yucatan and the southern states of Mexico are not rich in sculptures, apart from architecture; but in the valley of Mexico the human figure, animal forms, fanciful life motives in endless variety, were embodied in masks, yokes, tablets, calendars, cylinders, disks, boxes, vases, and ornaments. The Nahuatl lapidary had at hand many varieties of workable and beautiful stone; onyx, marble, limestone, quartz and quartz crystal, granite, syenite, basalt, trachyte, rhyolite, diorite, and obsidian, the best of material prepared for them by nature; while the Mayas had only limestone, and hard, tenacious rock with which to work it, and timber for burning lime. However, looking over the whole field of North American achievement, architectural and non-architectural, composite and monolithic, the palm for boldness, magnitude of proportions, and infinity of labour, must go to the sculptured mosaics of Yucatan. Maya architecture is the best remaining index of the art achievements of the American race. The construction of such buildings as the palace at Uxmal and the castillo at Chichen indicates a mastery in architectural design. There is lack of unity in plan and grouping, and an enormous waste of material as compared with available room. At Uxmal the mass of masonry is to chamber space about as forty to one. The builders were "ignorant of some of the most essential principles of construction, and are to be regarded as hardly more than novices in the art" (Holmes). As for the marvels of Peru, the walls of the temple of the sun in Cuzco, with their circular form and curve inward, from the ground upward, are most imposing. Some of the gates without lintels are beautiful, and the geometric patterns in the walls extremely effective. The same objection to over-massiveness might not apply here as in Mexico, owing to volcanic activity.

Sociology. Institutions in Europe and America have gathered abundant material for an intelligent comprehension of American Indian sociology. The British Association has had a committee reporting during many years on the tribes of North-west Canada. The American Museum in New York has prepared a series of monographs on the tribes of the North Pacific coast, of Northern Mexico, and of the Cordilleras of South America. The reports of the Bureau of Ethnology in Washington cover the Eskimo, east and west, and all the tribes of the United States. In Mexico the former labours of Pimentel and Orozco y Berra are supplemented by those of Bandelier, Peñafiel, Herrera, and Cicero. Otto Stoll's studies in Guatemala, Berendt's in Central America, Ernst's in Venezuela, Im Thurn's in Guiana, those of Ehrenreich, von den Steinen, Meyer in Brazil, or of Bandelier, Bastian, Brühl, Middendorf, von Tschudi in Peru, afford the historian of comparative sociology ample groundwork for a comprehensive grasp of South American tribes. In all parts of the western hemisphere society was organized on cognate kinship, real or artificial, the unit being the clan. There were tribes where the basis of kinship was agnate, but these were the exceptions. The headship of the clan was sometimes hereditary, sometimes elective, but each clan had a totemic name, and the clans together constituted the tribe, the bond being not land, but blood. Women could adopt prisoners of war, in which case the latter became their younger sons. When a confederacy was organized under a council, intermarriage between tribes sometimes occurred; an artificial kinship thus arose, in which event the council established the rank of the tribes as elder and younger brother; grandfather, father, and sons, rendering the relationship and its vocabulary most intricate, but necessary in a social system in which age was the predominant consideration and etiquette most exacting.

The Eskimo have a regular system of animal totem marks and corresponding gentes. Powell sets forth the laws of real and artificial kinship among the North American tribes, as well as tribal organization and government, the formation of confederacies, and the intricate rules of artificial kinship by which rank and courtesy were established. Bandelier declares that in Mexico existed neither state nor nation, nor political society of any kind, but tribes representing dialects, and autonomous in matters of government, and forming confederacies for the purposes of self-defence and conquest. The ancient Mexican tribe was composed of twenty autonomous kins. According to Brinton the social organization of ancient Peru was a government by a council of the gentes. The Inca was a war chief elected by the council to carry out its commands. Among the Caribs a like social order prevailed; indeed, their family system is identical with the totem system of North American Indians. Dominated by the rule of blood relationship, the Indians regulated all co-operative activities on this basis. Not only marriage, but speech and common industries, such as rowing a boat or chasing a buffalo, were under its sway. It obtrudes itself in fine art, behaviour, law-making, lore, and religion. In larger or smaller numbers of cognate kindred, for shorter or longer periods of time, near or far from home, the aborigines developed their legislatures, courts, armies, secret societies, and priesthoods.

Art of war.

In organization, engineering, strategy, offence, and defence, the art of war was in the barbarous and the savage status or grade. One competent to judge asserts that peace, not war, was the normal intertribal habit. They held frequent intercourse, gave feasts and presents, and practised unbounded hospitality. Through this traffic objects travelled far from home, and now come forth out of the tombs to perplex archæologists. Remembering the organization of the tribe everywhere prevalent, it is not difficult to understand that the army, or horde, that stands for the idea, was assembled on the clan basis. The number of men arrayed under one banner, the time during which they might cohere, the distances from home they could march, their ability to hold permanently what they had gained, together form an excellent metric scale of the culture grade in the several American provinces, and nowhere, even in the most favoured, is this mark high. With the Mexicans war was a passion, but warfare was little above the raid (Bandelier). The lower tribes hunted their enemies as they hunted animals. In their war dances, which were only rehearsals, they disguised themselves as animals, and the pantomime was a mimic hunt. They had striking, slashing, and piercing weapons held in the hand, fastened to a shaft or thong, hurled from the hand, from a sling, from an atlatl or throwing-stick, or shot from a bow. Their weapons were all individual, not one co-operative device of offence being known among them, although they understood fortification.

The term "slavery" is often applied to the aboriginal American tribes. The truth of this depends upon the definition of the word "slave." If it means the capture of men, and especially of women, and adoption into the tribe, this existed everywhere; but if subjection to a personal owner, who may compel service or sell the individual, slavery was far from universal. Nieboer finds it only on the North Pacific coast as far south as Oregon, among the Navajo and the Cibola pueblos, and in a few tribes of Middle and South America.

Lore.

The thought life of the American aborigines is expressed in their practical knowledge and their lore. The fascination which hangs around the latter has well-nigh obscured the former. As in medicine theory is one thing and practice another, so among these savages must the two be carefully discriminated. Dorsey, again, draws a distinction between lore narratives, which can be rehearsed without fasting or prayer, and rituals which require the most rigid preparation. In each culture province the Indians studied the heavenly bodies. The Arctic peoples regulated their lives by the long day and night in the year; among the tribes in the arid region the place of sunrise was marked on the horizon for each day; the tropical Indians were not so observant, but they worshipped the sun god above all. The Mayas had a calendar of 360 days, with intercalary days; this solar year was intersected by their sacred year of twenty weeks of thirteen days each, and these assembled in bewildering cycles. Their knowledge of the air and its properties was no less profound. Heat and cold, rain and drought, the winds in relation to the points of the compass, were nearest their wants and supplies, and were never out of their thoughts. In each province they had found the best springs, beds of clay, paint, soapstone, flinty rock, friable stone for sculpture, and hard, tenacious stone for tools, and used ashes for salt. The vegetal kingdom was no less familiar to them. Edible plants, and those for dyes and medicines, were on their lists, as well as wood for tools, utensils, and weapons, and fibres for textiles. They knew poisonous plants, and could eliminate noxious properties. The universal reliance on animal life stimulated the study of the animal kingdom. Everywhere there were names for a large number of species; industries and fine arts were developed through animal substances. Society was organized in most cases on animal clans, and religion was largely zoomorphic. The hunting tribes knew well the nature and habits of animals, their anatomy, their migrations, and could interpret their voices. Out of this practical knowledge, coupled with the belief in personeity, grew a folk-lore so vast that if it were written down the world would not contain the books.

Religion.

The religion of the American aborigines, so far as it can be made a subject of investigation, consisted (1) in what the tribes believed about spirits, or shades, and the spirit world—its organization, place, activities, and relation to our world; and (2) in what they did in response to these beliefs. The former was their creeds, the latter their cults or worships. In these worships, social organization, religious dramas and paraphernalia, amusement and gambling, and private religion or fetichism, found place. In order to obtain an intelligent grasp of the religion of tribes in their several culture provinces, it must be understood: (1) That the form of belief called *animism* by Tylor (more correctly speaking, *personeity*), was universal; everything was somebody, alive, sentient, thoughtful, wilful. This personeity lifts the majority of earthly phenomena out of the merely physical world and places them in the spirit world. Theology and science are one. All is supernatural, *wakañ*. (2) That there existed more than one self or soul or shade in any one of these personalities, and these shades had the power not only to go away, but to transform their bodily tenements at will; a bird, by raising its head, could become a man; the latter, by going on all fours, could become a deer. (3) That the regulative side of the spirit world was the natural outcome of the clan social system and the tribal government in each tribe. Even one's personal name had reference to the world of ghosts. The affirmation that American aborigines believed in an all-pervading, omnipotent Spirit is entirely inconsistent with the very nature of the case. (4) Worship was everywhere dramatic. Only here and there among the higher tribes were bloody sacrifices in vogue, and prayers were in pantomime.

In the culture areas the environment gave specific characters to the religion. In the Arctic province the overpowering influence of meteorological phenomena manifested itself both in the doctrine of shades and in their shamanistic practices. The raven created the world. The Déné myths resembled those of the Eskimo, and all the hunting tribes of Eastern Canada and United States and the Mississippi Valley have a mythology based upon their zootechny and their totemism. The religious conceptions of the fishing tribes on the Pacific coast between Mount St Elias and the Columbia river are worked out by Boas; the transformation from the hunting to the agricultural mode of life was accompanied by changes in belief and worship quite as radical. These have been carefully studied by Cushing, Stevenson, and Fewkes. The pompous ceremonials of the civilized tribes of Mexico and the Cordilleras in South America, when analysed, reveal only a higher grade of the prevailing idea. Im Thurn says of the Carib: "All objects, animate and inanimate, seem exactly of the same nature, except that they differ in the accident of bodily form." These mythological ideas and symbols of the American aborigines were woven in their textiles, painted on their robes and furniture, burned into their pottery, drawn in sand mosaics on deserts, and perpetuated in the only sculptures worthy of the name, in wood and stone. They are inseparable from industry; language, social organization, and custom wait upon them: they explain the universe in the savage mind.

Archæology.

The archæology of the western hemisphere should be divided as follows: (1) that of Indian activities; (2) the question of man's existence in a prior geological period. There is no dividing line between first-contact ethnology and pre-contact archæology. Historians of this time, both north and south of Panama, described tools and products of activities similar to those taken from beneath the soil near by. The archæologist recovers his specimens from waste places, cave deposits, abandoned villages, caches, shell-heaps, refuse heaps, enclosures, mounds, hut rings, earthworks, garden beds, quarries and workshops, petroglyphs, trails, graves and cemeteries, cliff and cavate dwellings, ancient pueblos, ruined stone dwellings, forts and temples, canals or reservoirs. The relics found in these places are material records of language, industries, fine arts, social life, lore, and religion.

Here and there in the Arctic province remains of old village sites have been examined, and collections brought away by whalers and exploring expeditions. Two facts are established—namely, that the Eskimo lived formerly farther south on the Atlantic coast, and that, aboriginally, they were not specially adept in carving and etching. The old apparatus of hunting and fishing is quite primitive. The Déné province in Alaska and North-western Canada yields nothing to the spade. Algonkin-Iroquois Canada, thanks to the Geological Survey and the Department of Education in Ontario, has revealed old Indian camps, mounds, and earthworks along the northern drainage of Lakes Erie and Ontario, and pottery in a curved line from Montreal to Lake of the Woods. Throughout Eastern United States shell-heaps, quarries, workshops, and camp sites are in abundance. The Sioux and the Muskhogee province is the mound area, which extends also into Canada along the Red river. The forms of these are earth-heaps, conical mounds, walls of earth, rectangular pyramids, and effigies. Thomas sums up the work of the Bureau of Ethnology upon the structure, contents, and distribution of these earth monuments, over a vast area from which adobe, building stone, and stone-working material were absent. No writings have been recovered, the artizans shaping small objects in stone were specially gifted, the potters in only a few places approached those of the Pueblos, the fine art was poor, and relics found in the mounds do not indicate in their makers a grade of culture above that of the Indian tribes near by. The archæology of the Pacific slope, from the Aleutian Islands, is written in shell-heaps, village sites, caves, and burial-places. The relics of bone, antler, stone, shell, and copper are of yesterday. Even the Calaveras man is no exception, since his skull and his polished conical pestle, the latter made of stone more recent than the auriferous gravels, show him to have been of Digger Indian type. In Utah begin the ruins of the Pueblo culture. These cover Arizona and New Mexico, with extensions into Colorado on the north and Mexico on the south. The reports of work done in this province for several years past form a library of text and illustration. Cliff dwellings, cavate houses, pueblos, and casas are all brought into a series without a break by Bandelier, Cushing, Fewkes, Holmes, Mindeleff, Nordenskiöld, Powell, and Stevenson. From Casa Grande, in Chihuahua, to Quemada, in Zacatecas, Lumholtz found survivals of the cliff dwellers. Between Quemada and Copan, in Honduras, is an unbroken series of mural structures. The traditions agree with the monuments, whatever may be objected to assigning any one ruin to the Toltec, the Chichimec, or the Nahuatl, that there are distinct varieties in ground-plan, motives, stone-craft, wall decorations, and sculptures. Among these splendours in stone the following recent explorers must be the student's guide:—Charnay, Förstemann, Goodman, Gordon, Holmes, Maudslay, Mercer, Sapper, Saville, Seler, Thomas, Thompson. A list of the ruins, printed in the handbook on Mexico published by the Department of State in Washington, covers several pages. The special characteristics of each are to be seen partly in the skill and genius of their makers, and partly in the exigencies of the site and the available materials. A fascinating study in this connexion is that of the water-supply. The cenotes or underground reservoirs were the important factors in locating the ruins of Northern Yucatan. From Honduras to Panama the urn burials, the pottery, the rude carved images, and, above all, the grotesque jewellery, absorb the archæologist's attention.

Beyond Chiriqui southward is El Dorado. Here also bewildering products of ancient metallurgy tax the imagination as to the processes involved, and questions of acculturation also interfere with true scientific results. The fact remains, however, that the curious metal craft of the narrow strip along the Pacific from Mexico to Titicaca is the greatest of archæological enigmas. Bandelier, Holmes, Seler, and Uhle have taken up the questions anew. Beyond Colombia are Ecuador and Peru, where, in the widening of the continent, architecture, stone-working, pottery, metallurgy, textiles, are again exalted. Among the Cordilleras in their western and interior drainages, over a space covering more than twenty degrees of latitude, the student comes again upon massive ruins. The materials on the coast were clay and gravel, wrought into concrete, sun-dried bricks, and pisé or rammed work, cut stalks of plants formed with clay a kind of staff, and lintels were made by burying stems of caña brava (*Gynerium saccharoides*) in blocks of pisé. On the uplands structures were of stone laid up in a dozen ways. Walls for buildings, garden terraces, and aqueducts were straight or sloping. Doorways were usually square, but corbelled archways and gateways surmounted with sculptures were not uncommon. Ornamentation was in carving and in colour, the latter far more effectively used than in Middle America. A glance at the exquisite textiles reveals at once the inspiration of mural decorations. The most prolific source of Peruvian relics is the sepulchres or huacas, the same materials being used in their construction as in building the houses. Here, owing to a dry climate, are the dead, clad and surrounded with food, vessels, tools, and art products, as in life. The textiles and the pottery can only be mentioned; their quality and endless varieties astonish the technologist. In the Carib province there are no mural remains, but the pottery, with its excessive onlaying, recalls Mexico and the jewellers of Chiriqui. The polished stone work is superb, finding its climax in Puerto Rico, which seems to have been the sacred island of the Caribs. For the coasts of South America the vast shell-heaps are the repositories of ancient history.

Palæolithic man.

Since 1880 organized institutions of anthropology have taken the spade out of the hands of individual explorers in order to know the truth concerning Glacial or Pleistocene man. The geologist and the trained archæologist are associated. In North America the sites have been examined by the Peabody Museum and the Bureau of Ethnology, with the result that only the Trenton gravels have any standing. The so-called palæolithic implements are everywhere. The question is one of geology, simply to decide whether those recovered at Trenton are ancient. Putnam and Wright maintain that they are ancient, Chamberlain and Holmes that they are post-Glacial, and comparatively recent. In South America the shell heaps, of enormous size, are supposed to show that the animals have undergone changes in size and that such vast masses require untold ages to accumulate. The first is a biological problem. As for the second, the elements of savage voracity and wastefulness, of uncertainty as to cubical contents on uneven surface, and of the number of mouths to fill, make it hazardous to construct a chronological table on a shell heap. Hudson's village sites in Patagonia contain pottery, and that brings them all into the territory of Indian archæology. Ameghino refers deposits in Patagonia, from which undoubted human bones and relics have been exhumed, to the Miocene. The question is of the age of the sediments from which these were taken. The bones of other associated animals, says Hatcher, demonstrate the Pleistocene nature of the deposits, by which is not necessarily meant older Quaternary, for their horizons have not been differentiated and correlated in South America. Hatcher believes that "there is no good evidence in favour of a great antiquity for man in Patagonia." In a cave near Consuelo Cove, Southern Patagonia, have been found fragments of the skin and bones of a large ground-sloth, *Grypotherium* (*Neomylodon*) *listai*, associated with human remains. Ameghino argues that this creature is still living, while Dr Moreno advances the theory that the animal has been extinct for a long period, and that it was domesticated by a people of great antiquity, who dwelt there prior to the Indians. Hauthal, Roth, and Nitsche review their work with the conclusion, not unanimously held by them, that man co-existed here with all the other animals whose remains were found during an inter-Glacial period. Woodward reviews the question in *Proceedings of the Zoological Society of London*, closing with this sentence: "If we accept the confirmatory evidence afforded by Mr Spencer Moore, we can hardly refuse to believe that this ground-sloth was kept and fed by an early race of men." These are individual opinions, subject to revision by that court of appeals, the institutional judgment.

AUTHORITIES.—A valuable endowment of research in specimens, literature, and pictures, deposited in libraries, museums, and galleries since 1880 will keep ethnologists and archæologists employed for many years to come. The scientific inquirer will find a mass of material in the papers and reports contributed to the various societies and institutions which are devoted to anthropological research. The following short list of works includes, however, a few authorities which have made use of recent discoveries generally:—H. H. BANCROFT. *Native Races of the Pacific States of North America*, vols. i.-v. 1874-1876. New York.—D. G. BRINTON. *Library of Aboriginal American Literature*, vols. i.-viii. 1882-1890. Philadelphia. *The American Race*. New York, 1891.—GUSTAV BRÜHL. *Die Culturvölker Amerikas*. Cincinnati, 1889.—DÉSIRÉ CHARNAY. *The Ancient Cities of the New World*. New York, 1887.—F. S. DELLENBAUGH. *The North Americans of Yesterday*. New York, 1901.—J. DENIKER. *The Races of Man*. London, 1900.—PAUL EHRENREICH. *Die Völkerstämme Brasiliens*. Berlin, 1892. *Anthropologische Studien über die Urbewohner Brasiliens*. Berlin, 1897.—J. W. FEWKES. *A Journal of American Ethnology and Archæology*, vols. i.-iv. Boston, 1891-94.—E. FÖRSTEMANN. *Zur Entzifferung der Maya Handschriften*, Parts i.-vii. Dresden, 1880, 1898. *Die Maya-Handschrift der Königl. öffent. Bibliothek zu Dresden*. Leipzig, 1880; Dresden, 1891.—E. F. IM THURN. *Among the Indians of Guiana*. London, 1883.—A. H. KEANE. *Ethnology*. Cambridge, 1896. *Man, Past and Present*. Cambridge, 1899.—WASHINGTON MATTHEWS. *Navajo Legends*. Cambridge, Mass., 1897.—ANNE CARY MAUDSLAY and ALFRED PERCIVAL. *A Glimpse at Guatemala, and some Notes on the Ancient Monuments of Central America*. London, 1899.—H. C. MERCER. *The Hill Caves of Yucatan*. Philadelphia, 1896.—MARQUIS DE NADAILLAC. *L'Amérique préhistorique*. Paris, 1883.—H. J. NIEBOER. *Slavery as an Industrial System*. Ethnological researches. The Hague, 1900.—G. NORDENSKIÖLD. *The Cliff Dwellers of the Mesa Verde, Colorado*. Stockholm, 1893.—EDWARD JOHN PAYNE. *History of the New World called America*, vol. i. 1892, vol. ii. 1899. Oxford.—DÉSIRÉ PECTOR. *Notes sur l'Américanisme; Quelques-unes de ses lacunes en 1900*. Paris, 1900.—J. W. POWELL. *The United States of America*. Ed. by N. S. S. Shaler. New York, 1894.—CYRUS THOMAS. *Introduction to the Study of North American Archæology*. Cincinnati, 1898.—JUSTIN WINSOR. *Narrative and Critical History of America*. Boston, 1889.—G. F. WRIGHT. *The Ice Age in North America*. New York, 1896.

(O. T. M.)

America Islands. See POLYNESIA.

American Literature. See under UNITED STATES.

Americus, a city of Georgia, U.S.A., the capital of Sumter county, situated in the south-western part of the state at an altitude of 360 feet. It is in an agricultural region which produces cotton and corn, and is on the Central of Georgia and the Georgia and Alabama railways. The population in 1880 was 3635, in 1890 it was 6398, and in 1900 it was 7674.

Amersham, or Agmondesham, a market-town and railway station in the Wycombe parliamentary division of Buckinghamshire, England, 26 miles W.N.W. of London. Area of parish, 6119 acres. Population (1881), 2500; (1901), 3209. Rural district area, 39,800 acres; population (1891), 12,501; (1901), 13,541.

Amesbury, a town of Essex county, Massachusetts, U.S.A., situated in north-eastern Massachusetts on the north bank of the Merrimac river, six miles from its mouth. Its area is fourteen square miles and its surface is hilly. The principal village, bearing the same name as the town, and noted as being the home of Whittier, lies at the mouth of the Powow river, and is on the Boston and Maine railway. The population of the town (1880) was 3355; (1890), 9798; (1900), 9473.

Amhara. See Abyssinia.

Amherst, a district and town within the Tenasserim division of Lower Burma, lying between the Indian Ocean and the hills which separate Burma from Siam. The area of the district is 7062 square miles, with, in 1891, a population of 233,539. The number of villages in the district was 660, and the revenue paid in 1898-99 was Rs.8,76,819. In 1891 the population comprised 191,241 Buddhists and Jains, 19,415 Hindus, 15,611 Mahommedans, 2897 aborigines, mostly Karens, and 4374 Christians. Of the total area of 4,519,680 acres, there were 312,908 acres under cultivation in 1898-99, 14,594 acres were fallow, 77,912 acres were cultivable, and 3,670,276 acres were not capable of cultivation. The chief town is Moulmein, with a population of 55,785. Amherst town, about 30 miles to the south, has not grown to any appreciable extent and remains a mere bathing-place for Moulmein. The rainfall for the district in 1898-99 was 199·58 inches. This is below the average.

Amherst, the county town of Cumberland county and port of entry in Nova Scotia, at the head of Chignecto Bay and on the Intercolonial Railway, 138 miles from Halifax. It contains county and railway buildings, six churches, an iron foundry and several factories, and shops for the manufacture of railway carriages. In 1900 the exports were $338,525, and the imports $219,422. The population in 1891 was 3781, and was estimated in 1900 at 5600.

Amherst, a town of Hampshire county, in central Massachusetts, U.S.A., with an area of 26 square miles. It is situated on the east side of Connecticut Valley, immediately north of Holyoke Range. The village of the same name is entered by two railways, the Boston and Maine and the Central Vermont. Amherst College had in 1899 a faculty of 32 professors and instructors, and was attended by 380 students. Its property was valued at $2,400,000, and its income was $100,000. The state Agricultural College had in 1899 a teaching staff of 19 professors and 140 students. The population in 1880 was 4298, in 1890 it was 4512, and in 1900 it was 5028.

Amiel, Henri Frédéric (1821-1881), Swiss philosopher and critic, was born at Geneva, 27th September 1821. He was descended from a Huguenot family which had been driven to Switzerland by the revocation of the Edict of Nantes. He lost both his parents at an early age; when he grew up he devoted himself principally to travel, mingling with the most intellectual circles throughout Europe, and in particular studying German philosophy at Berlin. In 1849 he was appointed professor of æsthetics at the academy of Geneva, and in 1854 became professor of moral philosophy. Notwithstanding his high qualifications, these appointments turned out unfortunately for him. They had been conferred by the democratic party, then dominant in Geneva, and he was in consequence entirely ignored by the aristocratic party, which comprised nearly all the culture and refinement of the city. This painful isolation nevertheless inspired the one book by which Amiel lives, the *Journal Intime*, which, published after his death, obtained a European reputation and was translated into English by Mrs Humphry Ward. Did not "second-rate" seem to imply a slur, this book might be well described by the title of one of Tennyson's early poems, "The Confessions of a Second-rate Sensitive Mind ill at ease with itself." Although, however, second-rate as regarded productive power, Amiel's mind was of no inferior quality, and his journal, as a candid record of the yearnings and meditations of a thoughtful, affectionate, and wounded spirit, gained a sympathy which the author had failed to obtain in his life. He also wrote studies on Erasmus, Madame de Staël, and other literary personages, and several volumes of poems. Amiel died in Geneva on the 27th of December 1881. (R. G.)

Amiens, the ancient capital of Picardy, and chief town of the department of Somme, France, situated on the river Somme, 81 miles from Paris by the Paris-Calais railway. It has also railway communication with Arras, Lille and Belgium, Tergnier and Rheims, Rouen and Normandy, Doullens, Beauvais and Crépy-en-Valois. The chief industries of the town are manufactures of cotton-velvet (value of annual production, £400,000) and Utrecht velvet (20,000 pieces, value £200,000 to £240,000 a year), cotton-spinning, wool-spinning (50,000 spindles), hemp- and flax-spinning (24,000 spindles), weaving, manufactures of hosiery, carpets, machinery, chemicals, sugar, and *nouveautés*, brewing, tanning, printing, and founding. The population of the town in 1886 was 68,177; in 1896, 74,808 (commune, 88,731); in 1901, 90,758.

Ammunition. See Propellants, and Ordnance.

Amoy, a town and treaty-port on the small island of Hiamen, province of Fuhkien, China. It has dry docks and an excellent anchorage. The trade in 1870 was: imports, £1,915,427; and exports, £1,440,000. In 1899 the figures were: imports, £2,180,000; and exports, £363,000. The falling off of exports is due to the decreased demand for China tea, for which Amoy was one of the chief centres. The native population is now estimated at 300,000, and the foreign residents number about 280. A large part of the trade is that carried on with the neighbouring island of Formosa, now Japanese. The province of Fuhkien is claimed by the Japanese as their particular sphere of influence.

Amphibia.—The arguments adduced by Huxley, in his article on this subject in the ninth edition of the *Encyclopædia Britannica*, for applying this name to those lung-breathing, pentadactyle vertebrates which had been first severed from the Linnæan *Amphibia* by Brongniart, under the name of *Batrachia*, have not met with universal acceptance. Although much used in text-books and anatomical works in Great Britain and in Germany, the former name has been discarded in favour of the latter by the principal authors on systematic herpetology, such as Peters, Günther, and Cope, and their lead is followed in the present article. Bearing in mind that Linnæus, in his use of the name Amphibia, was not alluding to the branchiate and pulmonate periods through which most frogs and newts pass in the course of their existence, but only wished to convey the fact that many of the constituents of the group resort to both land and water (*e.g.*, crocodiles), it seems hard to admit that the term may be thus diverted from its original signification, especially when such a change results in discarding the name expressly proposed by Brongniart to denote the association which has ever since been universally adopted either as an order, a subclass, or a class. Many authors who have devoted special attention to questions of nomenclature therefore think *Reptilia* and *Batrachia* the correct names of the two great classes into which the Linnæan *Amphibia* have been divided, and consider that the latter term should be reserved for the use of those who, like that great authority, the late Professor Peters, down to the time of his death in 1883, would persist in regarding reptiles and batrachians as mere sub-classes (**1**). However extraordinary it may appear, especially to those who bring the living forms only into focus, that opposition should still be made to Huxley's primary division of the vertebrates other than mammals into *Sauropsida* (birds and reptiles) and *Ichthyopsida* (batrachians and fishes), it is certain that recent discoveries in palæontology have reduced the gap between batrachians and reptiles to such a minimum as to cause the greatest embarrassment in the attempt to draw a satisfactory line of separation between the two; on the other hand the hiatus between fishes and batrachians remains as wide as it was at the time the article "Amphibia" was written. When we turn to the definition given in that article (*Ency. Brit.* vol. i. p. 750), we find that one of the essential characters—"two occipital condyles, the basi-occipital region of the skull either very incompletely, or not at all ossified"—may require revision, if it be true, as held by some authors, that the bone on which the occipital condyles have been found most developed, in some labyrinthodonts (**2**), represents a large basi-occipital bone yielding the two knobs for the articulation of the skull, whilst the skull of the batrachians of the present day has lost the basi-occipital, and the condyles are furnished by the exoccipitals. More than this, some reptiles are now known to have the occipital condyle divided into two, and produced either by the basi-occipital (*e.g.*, *Amphisbænidæ*, in some of which the double condyle resembles very closely that of the labyrinthodont *Bothriceps*), or by the exoccipitals (*e.g.*, *Uroplatidæ*). When we remember that the supposed condition of the occipital condyles was not very long ago thought sufficient to point to a possible direct descent of the mammals from the batrachians, we shall realize the full importance of the more correct information now available on this point. As a result of his researches on the anomodont reptiles and the *Stegocephalia* (**3**), as the extinct order that includes the well-known labyrinthodonts is now called, we have had the proposal by Seeley (**4**) to place the latter with the reptiles instead of with the batrachians; whilst Credner (**5**), basing his views on the discovery by him of various annectent forms between the Stegocephalia and the Rhynchocephalian reptiles, has proposed a class, *Eotetrapoda*, to include these forms, ancestors of the batrachians proper on the one hand, of the reptiles proper on the other. Yet, that the Stegocephalia, notwithstanding their great affinity to the reptiles, ought to be included in the batrachians as commonly understood, seems sufficiently obvious from the mere fact of their passing through a branchiate condition, *i.e.*, undergoing metamorphosis (**6**). The outcome of our present knowledge points to the Stegocephalia, probably themselves derived from the Crossopterygian fishes (**7**) having yielded on the one hand the true batrachians (retrogressive series), with which they are to a certain extent connected through the *Caudata* and the *Apoda*, on the other hand the reptiles (progressive series), through the Rhynchocephalians and the Anomodonts, the latter being believed, on very suggestive evidence, to lead to the mammals (**8**).

The division of the class Amphibia, or Batrachia, into four orders, as carried out by Huxley, is maintained, with, however, a change of names: *Stegocephalia*, for the assemblage of minor groups that cluster round the *Labyrinthodonta* of Owen, which name is restricted to the forms for which it was originally intended; *Peromela*, *Urodela*, *Anura*, are changed to *Apoda*, *Caudata*, *Ecaudata*, for the reason that (unless obviously misleading, which is not the case in the present instance) the first-proposed name should supersede all others for higher groups as well as for genera and species, and the latter set have the benefit of the law of priority. In the first subdivision of the batrachians into two families by Duméril in 1806 (*Zool. Anal.* pp. 90-94) these are termed "Anoures" and "Urodèles" in French, *Ecaudati* and *Caudati* in Latin. When Duméril's pupil, Oppel, in 1811 (*Ordn. Rept.* p. 72), added the Cæcilians, he named the three groups *Apoda*, *Ecaudata*, and *Caudata*. The Latin form being the only one entitled to recognition in zoological nomenclature, it follows that the last-mentioned names should be adopted for the three orders into which recent batrachians are divided.

I. **STEGOCEPHALIA** (**9**).—Tailed, lacertiform, or serpentiform batrachians, with the temporal region of the skull roofed over by postorbital, squamosal, and supratemporal plates similar to the same bones in Crossopterygian fishes, and likewise with paired bones (occipitals and post-temporals) behind the parietals and supratemporals. A parietal foramen; scales or bony scutes frequently present, especially on the ventral region, which is protected further by three large bony plates—interclavicle and clavicles, the latter in addition to cleithra.

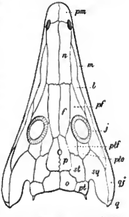


Fig. 1.—Upper view of *Archegosaurus Decheni*. (Outlines after Credner.) *pm*, præmaxilla; *n*, nasal; *m*, maxilla; *l*, lacrymal; *pf*, prefrontal; *f*, frontal; *j*, jugal; *ptf*, postfrontal; *p*, parietal; *st*, supratemporal; *sq*, squamosal; *pto*, postorbital; *qj*, quadrato-jugal; *o*, occipital; *pt*, post-temporal; *q*, quadrate.

Extinct, ranging from the Upper Devonian to the Trias. Our knowledge of Devonian forms is still extremely meagre, the only certain proof of the existence of pentadactyle vertebrates at that period resting on the footprints discovered in Pennsylvania and described by Marsh (**10**) as *Tinopus antiquus*. Sundry remains from Belgium, as to the identification of which doubts are still entertained, have been regarded by Lohest (**11**) as evidence of these batrachians in the Devonian. Over 200 species are now distinguished, from the Carboniferous of Europe and North America, the Permian of Europe, North America, and South Africa, and the Trias of Europe, America, South Africa, India, and Australia. The forms of batrachians with which we are acquainted show the vertebral column to have been evolved in the course of time from a notochordal condition with segmented centra similar to that of early bony Ganoid fishes (*e.g.*, *Caturus*, *Eurycormus*) to biconcave centra, and finally to the socket-and-ball condition that prevails at the present day. However, owing to the evolution of the vertebral column in various directions, and to the inconstant state of things in certain annectent groups, it is not possible, it seems, to apply the vertebral characters to taxonomy with that rigidity which Cope and some other recent authors have attempted to enforce. This is particularly evident in the case of the Stegocephalians; and recent batrachians, tailed and tailless, show the mode of articulation of the vertebræ, whether amphicœlous, opisthocœlous, or procœlous, to be of but secondary systematic importance in dealing with these lowly vertebrates. The following division of the Stegocephalians into five sub-orders is therefore open to serious criticism; but it seems on the whole the most natural to adopt in the light of our present knowledge.

A. Rhachitomi (Figs. 1, 2), in which the spinal cord rests on the notochord, which persists uninterrupted and is surrounded by three bony elements in addition to the neural arch: a so-called pleurocentrum on each side, which appears to represent the centrum proper of reptiles and mammals, and an intercentrum or hypocentrum below, which may extend to the neural arch, and probably answers to the hypapophysis, as it is produced into chevrons in the caudal region. Mostly large forms, of Carboniferous and Permian age, with a more or less complex infolding of the walls of the teeth. Families: ARCHEGOSAURIDÆ, ERYOPIDÆ, TRIMERORHACHIDÆ, DISSORHOPHIDÆ. The last is remarkable for an extraordinary endo- and exo-skeletal carapace, *Dissorhophus* being described by Cope (**12**) as a "batrachian armadillo."

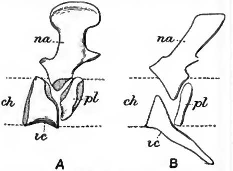


FIG. 2.—A, Dorsal vertebra, B, Caudal vertebra of *Archegosaurus*. (Outline after Jaekel.) *na*, neural arch; *ch*, chorda; *pl*, pleurocentrum; *ic*, intercentrum.

B. Embolomeri, with the centra and intercentra equally developed discs, of which there are thus two to each neural arch; these discs perforated in the middle for the passage of the notochord. This type may be directly derived from the preceding, with which it appears to be connected by the genus *Diplospondylus*. Fam.: CRICOTIDÆ, Permian.

C. Labyrinthodonta, with simple biconcave vertebral discs, very slightly pierced by a remnant of the notochord and supporting the loosely articulated neural arch. This condition is derived from that of the *Rhachitomi*, as shown by the structure of the vertebral column in young specimens. Mostly large forms from the Trias (a few Permian), with true labyrinthic dentition. Families: LABYRINTHODONTIDÆ, ANTHRACOSAURIDÆ, DENDRERPETIDÆ, NYRANIIDÆ.

D. Microsauria, nearest the reptiles, with persistent notochord completely surrounded by constricted cylinders on which the neural arch rests. Teeth hollow, with simple or only slightly folded walls. Mostly of small size and abundant in the Carboniferous and Lower Permian. Families: UROCORDYLIDÆ, LIMNERPETIDÆ, HYLONOMIDÆ, (Fig. 3) MICROBRACHIDÆ, DOLICHOSOMATIDÆ; the latter serpentiform, apodal.

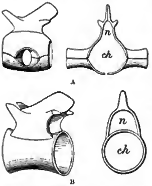


FIG. 3.—A, Dorsal vertebra of *Hylonomus* (side view and front view). B, Dorsal vertebra of *Branchiosaurus* (side view and front view). (After Credner.) *n*, neural canal; *ch*, chorda.

E. Branchiosauria, nearest to the true batrachians; with persistent, non-constricted notochord, surrounded by barrel-shaped, bony cylinders formed by the neural arch above and a pair of intercentra below, both these elements taking an equal share in the formation of a transverse process on each side for the support of the rib. This plan of structure, apparently evolved out of the rhachitomous type by suppression of the pleurocentra and the downward extension of the neural arch, leads to that characteristic of frogs in which, as development shows, the vertebra is formed wholly or for the greater part by the neural arch (**13**). Small forms from the Upper Carboniferous and Permian formations. A single family: BRANCHIOSAURIDÆ.

II. APODA (14).—No limbs. Tail vestigial or absent. Frontal bones distinct from parietals; palatines fused with maxillaries. Male with an intromittent copulatory organ. Degraded, worm-like batrachians of still obscure affinities, inhabiting tropical Africa, South-eastern Asia, and tropical America. Thirty-three species are known. No fossils have yet been discovered. It has been attempted of late to do away with this order altogether and to make the Cæcilians merely a family of the Urodeles. This view has originated out of the very remarkable superficial resemblance between the *Ichthyophis*-larva and the *Amphiuma*. Cope (**15**) regarded the Apoda as the extremes of a line of degeneration from the Salamanders, with *Amphiuma* as one of the annectent forms. In the opinion of the cousins Sarasin (**16**), whose great work on the development of *Ichthyophis* is one of the most important recent contributions to our knowledge of the batrachians, *Amphiuma* is a sort of neotenic Cæcilian, a larval form become sexually mature while retaining the branchial respiration. If the absence of limbs and the reduction of the tail were the only characteristic of the group, there would be, of course, no objection to unite the Cæcilians with the Urodeles; but, to say nothing of the scales, present in many genera of Apodals and absent in all Candates, which have been shown by Credner to be identical in structure with those of Stegocephalians, the Cæcilian skull presents features which are not shared by any of the tailed batrachians. G. M. Winslow (**17**), who has made a study of the chondrocranium of *Ichthyophis*, concludes that its condition could not have been derived from a Urodele form, but points to some more primitive ancestor. That this ancestor was nearly related to, if not one of the Stegocephalians, future discovery will in all probability show.

III. CAUDATA (18).—Tailed batrachians, with the frontals distinct from the parietals and the palatines from the maxillary. Some of the forms breathe by gills throughout their existence, and were formerly regarded as establishing a passage from the fishes to the air-breathing batrachians. They are now considered as arrested larvæ descended from the latter. One of the most startling discoveries of the decade 1890-1900 was the fact that a number of forms are devoid of both gills and lungs, and breathe merely by the skin and the buccal mucose membrane (**19**). Three blind cave-forms are known: one terrestrial—*Typhlotriton*, from North America, and two perennibranchiate—*Proteus* in Europe and *Typhlomolge* (Fig. 4) in North America.

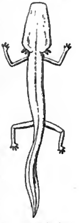


FIG. 4.—*Typhlomolge rathbuni.*

This order contains about 150 species, referred to five families: HYLÆOBATRACHIDÆ, SALAMANDRIDÆ, AMPHIUMIDÆ, PROTEIDÆ, SIRENIDÆ.

Fossil remains are few in the Upper Eocene and Miocene of Europe and the Upper Cretaceous of North America. The oldest Urodele known is *Hylæobatrachus*, Dollo (**20**) from the Lower Wealden of Belgium. At present this order is confined to the northern hemisphere, with the exception of two *Spelerpes* from the Andes of Ecuador and Peru, and a *Plethodon* from Argentina.

IV. ECAUDATA (**21**).—Frogs and toads. Four limbs and no tail. Radius confluent with ulna, and tibia with fibula; tarsus (astragalus and calcaneum) elongate, forming an additional segment in the hind limb. Caudal vertebræ fused into a urostyle or coccyx. Frontal bones confluent with parietals.

This order embraces about 1300 species, of which some 40 are fossil, divided into two sub-orders and sixteen families:—

A. Aglossa.—Eustachian tubes united into a single ostium pharyngeum; no tongue. DACTYLETHRIDÆ, PIPIDÆ.

B. Phaneroglossa.—Eustachian tubes separated; tongue present. DISCOGLOSSIDÆ, PELOBATIDÆ, HEMIPHRACTIDÆ, AMPHIGNATHODONTIDÆ, HYLIDÆ, BUFONIDÆ, DENDROPHRYNISCIDÆ, CYSTIGNATHIDÆ, DYSCOPHIDÆ, GENYOPHRYNIDÆ, ENGYSTOMATIDÆ, CERATOBATRACHIDÆ, RANIDÆ, DENDROBATIDÆ.

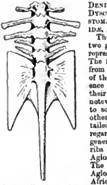


FIG. 5.—Vertebral column of *Hymenochirus* (ventral view).

The Phaneroglossa are divided into two groups: *Arcifera* and *Firmisternia*, representing two stages of evolution. The family characters are mainly derived from the dilatation or non-dilatation of the sacral diapophyses, and the presence of teeth in one or both jaws, or their absence. The *Discoglossidæ* are noteworthy for the presence of short ribs to some of the vertebræ, and in some other points, also, they approach the tailed batrachians; they may be safely regarded as, on the whole, the most generalized of known Ecaudata. Distinct ribs are present at an early age in the Aglossa, as discovered by Ridewood (22). The recent addition of a third genus of Aglossa, *Hymenochirus* (23) from tropical Africa, combining characters of *Pipa* and *Xenopus*, has removed every doubt as to the real affinity which connects these genera. *Hymenochirus* is further remarkable for the presence of only six distinct pieces in the vertebral column, which is thus the most abbreviated among all vertebrata (Fig. 5).

Apart from a few unsatisfactory remains from the Eocene of Wyoming, fossil tailless batrachians are only known from the Oligocene, Miocene, and Pliocene of Europe and India. These forms differ very little from those that live at the present day in the same part of the world, and some of the genera (*Discoglossus*, *Bufo*, *Oxyglossus*, *Rana*) are even identical. *Palæobatrachus* (24), of which a number of species represented by skeletons of the perfect form and of the tadpole have been described from Miocene beds in Germany, Bohemia, and France, seems to be referable to the *Pelobatidæ*; this genus has been considered as possibly one of the Aglossa, but the absence of ribs in the larvæ speaks against such an association.

Since the publication of the article AMPHIBIA numerous additions have been made to our knowledge of the development and nursing habits, which are extremely varied, some forms dispensing with or hurrying through the metamorphoses and hopping out of the egg in the perfect condition (25).

(1) On the use of the names *Batrachia* and *Amphibia*, *cf.* E. D. COPE, *Geol. Mag.* (3) ii. 1885, p. 575; G. BAUR, *Science* (2) vi. 1897, pp. 170, 372; B. G. WILDER, *l. c.* p. 295; T. GILL, *l. c.* p. 446; G. P. HAY, *l. c.* p. 773. (2) E. FRAAS, "Die Labyrinthodonten der Schwäbischen Trias," *Palæontogr.* xxxvi. 1889, p. 1. (3) E. D. COPE, "Synopsis of the Extinct Batrachia of North America." *Proc. Ac. Philad.* 1868, p. 208. (4) "Researches on the Structure, Organization, and Classification of the Fossil Reptilia, vii." *Phil. Trans.* clxxxiii. (B) 1892, p. 311. (5) "Die Urvierfüssler (*Eotetrapoda*) des Sächsischen Rothliegenden." *Allgem. verständl. naturw. Abh.*, Berlin, 1891, No. 15. (6) H. CREDNER. "Die Entwicklungsgeschichte von *Branchiosaurus amblystomus*." *Zeitschr. Deutsch. Geol. Ges.* 1886, p. 576. (7) C. EMERY. "Ueber die Beziehungen des Chiropterygium zum Ichthyopterygium." *Zool. Anz.* x. 1887, p. 185.—E. D. COPE. "On the Phylogeny of the Vertebrata." *Proc. Amer. Philos. Soc.* xxx. 1892, p. 280.—H. B. POLLARD. "On the Anatomy and Phylogenetic Position of *Polypterus*." *Zool. Jahrb. Anat.* v. 1892, p. 414.—G. BAUR. "The Stegocephali: a Phylogenetic Study," *Anat. Anz.* xi. 1896, p. 657.—L. DOLLO. "Sur la Phylogénie des Dipneustes." *Mém. Soc. Belge Géol.* ix. 1895, p. 79.—T. GILL. "On the Derivation of the Pectoral Member in Terrestrial Vertebrates." *Rep. Brit. Ass.* 1897, p. 697. (8) E. D. COPE. "The Origin of the Mammalia." *Proc. Amer. Philos. Soc.* xxii. 1884, p. 43.—*Cf.* Discussion on Origin of Mammals, *Proc. Intern. Congr. Zool.*, Cambridge, 1898. (9) A. FRITSCH. *Fauna der Gaskohle und der Kalksteine der Permformation Böhmens.* Vols. i. and ii. Prague: 1879-85, 4to.—H. CREDNER. "Die Stegocephalen aus dem Rothliegenden des Plauenschen Grundes bei Dresden." *Zeitschr. Deutsch. Geol. Ges.* 1881-1894.—J. W. DAWSON. "On the Results of Recent Explorations of Erect Trees containing Animal Remains in the Coal Formation of Nova Scotia." *Phil. Trans.* clxxiii. 1882, p. 621.—H. B. GEINITZ and J. V. DEICHMÜLLER. "Die Saurier der Unteren Dyas von Sachsen." *Palæontogr.* xxix. 1882, p. 1.—A. GAUDRY. *Les Enchaînements du Monde animal dans les temps géologiques. Fossiles primaires* (Paris: 1883, 8vo), p. 251.—E. D. COPE. "The Batrachia of the Permian Period of North America." *Amer. Nat.* xviii. 1884, p. 26.—E. FRAAS. "Die Labyrinthodonten der Schwäbischen Trias." *Palæontogr.* xxxvi. 1889, p. 1.—L. v. AMMON. Die Permischen Amphibien der Rheinpfalz. Munich: 1889 (1891), 4to.—R. LYDEKKER. *Catalogue of the Fossil Reptilia and Amphibia in the British Museum.* Part IV. London: 1890, 8vo.—E. FRAAS. *Die Schwäbischen Trias-Saurier nach dem Material der K. Naturalien-Sammlung in Stuttgart zusammengestellt.* Stuttgart: 1896, 4to.—O. JAEKEL, "Die Organization von *Archegosaurus*." *Zeitschr. Deutsch. Geol. Ges.* xlviii. 1896, p. 505.—F. BROILI. "Ein Beitrag zur Kenntniss von *Eryops megacephalus*." *Palæontogr.* xlvi. 1899, p. 61. (10) "Amphibian Footprints from the Devonian." *Amer. Journ. Sci.* ii. 1896, p. 374. (11) "Découverte du plus ancien Amphibien connu . . . dans le Famennien supérieur de Modava." *Bull. Soc. Belge Géol.* xv. 1888, p. cxx. (12) "A Batrachian Armadillo." *Amer. Nat.* xxix. 1895, p. 998. (13) C. GEGENBAUR. *Untersuchungen zur vergleichenden Anatomie der Wirbelsäule bei Amphibien und Reptilien.* Leipzig: 1862, 4to.—H. GADOW. "On the Evolution of the Vertebral Column of Amphibia and Amniota." *Phil. Trans.* clxxxvii. B. 1896, p. 1. (14) R. WIEDERSHEIM. *Die Anatomie der Gymnophionen.* Jena, 1879, 4to. W. PETERS. "Ueber die Eintheilung der Cæcilien." *Mon. Berl. Ac.* 1879, p. 924.—G. A. BOULENGER. *Catalogue of Batrachia Gradientia s. Caudata and Batrachia Apoda in the Collection of the British Museum.* London: 1882, 8vo, and "A Synopsis of the Genera and Species of Apodal Batrachians." *P. Z. S.* 1895, p. 401. (15) "On the Structure and Affinities of the *Amphiumidæ*." *Proc. Amer. Philos. Soc.* xxiii. 1888, p. 442. (16) *Ergebnisse naturwissenschaftlicher Forschungen auf Ceylon*, ii. Wiesbaden: 1887-90, 4to. (17) "The Chondrocranium of the Ichthyopsida." *Stud. Biol. Lab. Tufts Coll.* No. 5, 1898, p. 147. (18) G. A. BOULENGER. *Catalogue, l. c.* 1882. (19) H. H. WILDER. "Lungenlose Salamandriden." *Anat. Anz.* ix. 1894, p. 216.—L. CAMERANO. "Ricerche anatomo-fisiologiche intorno ai Salamandridi normalmente apneumoni." *Atti Acc. Torin.* xxix. 1894, p. 705, and xxxi. 1896, p. 512.—H. H. WILDER. "Lungless Salamanders." *Anat. Anz.* xii. 1896, p. 182.—E. LOENNBERG. "Notes on Tailed Batrachians without Lungs." *Zool. Anz.* xix. 1896, p. 33. (20) "Note sur le Batracien de Bernissart." *Bull. Mus. Belg.* iii. 1884, p. 85. (21) G. A. BOULENGER. *Catalogue of Batrachia Salientia s. Ecaudata in the Collection of the British Museum.* London: 1882, 8vo. (22) "On the Development of the Vertebral Column in *Pipa* and *Xenopus*." *Anat. Anz.* xiii. 1898, p. 359. (23) G. A. BOULENGER. "On *Hymenochirus*, a New Type of Aglossal Batrachians." *Ann. and Mag. N. H.* (7) iv. 1899, p. 122.—W. G. RIDEWOOD. "On the Hyobranchial Skeleton and Larynx of the New Aglossal Toad, *Hymenochirus boettgeri*." *J. Linn. Soc.* xxvii. 1900, p. 454. (24) W. WOLTERSTORFF. "Ueber fossile Frösche, insbesondere *Palæobatrachus*." *Jahresb. Nat. Ver. Magdeb.* 1885 and 1886. (25) W. PETERS. "Ueber die Entwickelung eines Batrachiers, *Hylodes martinicensis*, ohne Metamorphose." *Mon. Berl. Ac.* 1876, p. 709.—A. KAPPLER. "Die Tierwelt in Holländischen Guiana." *Das Ausland*, 1885, p. 358. G. A. BOULENGER. "Reptiles and Batrachians of the Solomon Islands." *Trans. Zool. Soc.* xii. 1886, p. 51.—H. v. IHERING. "On the Oviposition of *Phyllomedusa iheringii*." *Ann. and Mag. N. H.* (5) xvii. 1888, p. 461.—H. H. SMITH. "On Oviposition and Nursing in the Batrachian genus *Dendrobates*." *Amer. Nat.* xxi. 1887, p. 307.—G. B. HOWES. "Notes on the Gular Brood-pouch of *Rhinoderma darwini*." *P. Z. S.* 1888, p. 231.—W. J. HOLLAND. "Arboreal Tadpoles." *Amer. Nat.* xxiii. 1889, p. 383.—E. A. GOELDI. "Contribution to the Knowledge of the Breeding Habits of some Tree-frogs of the Serra dos Orgãos, Rio de Janeiro, Brazil." *P. Z. S.* 1895, p. 89.—G. A. BOULENGER. "On the Nursing Habits of two South American Frogs." *P. Z. S.* 1895, p. 209.—A. BRAUER. "Ein neuer Fall von Brutpflege bei Fröschen." *Zool. Jahrb. Syst.* xi. 1898, p. 89.—S. IKEDA. "Notes on the Breeding Habit and Development of *Rhacophorus schlegelii*." *Annot. Zool. Japon.* i. 1898, p. 113.

(G. A. B.)

Amphioxus.—Amphioxus has been briefly treated under the headings ICHTHYOLOGY, LANCELET, and VERTEBRATA in the ninth edition of this work. Such, however, is its importance in the present zoological system that a more extended notice is desirable. The theoretical interest of Amphioxus depends upon a variety of circumstances. In its manner of development from the egg, and in the constitution of its digestive, vascular, respiratory (branchial), excretory, skeletal, nervous, and muscular systems it exhibits what appears to be a primordial condition of vertebrate organization, a condition which is, in fact, partly recapitulated in the course of the embryonic stages of craniate vertebrates. In comparative morphology it provides many illustrations of important biological principles (such, for example, as substitution and change of function of organs), and throws new light upon, or at least points the way to new ideas of the primitive relations of different organic systems in respect of their function and topography. One of the most puzzling features in its structure, and, at the same time, one of the greatest obstacles to the view that it is essentially primitive and not merely a degenerate creature, is the entire absence of the paired organs of special sense, olfactory, optic, and auditory, which are so characteristic of the higher vertebrates. Although it is true that there is a certain amount of gradation in the degree of development to which these organs have attained in the various orders, yet it is hardly sufficient to enable the imagination to bridge over the gap which separates Amphioxus from the lowest fishes in regard to this feature of organization.

Classification.—On account of the absence of anything in the nature of a skull, Amphioxus has been regarded as the type of a division, *Acrania*, in contrast with the *Craniota* which comprise all the higher Chordata. The ordinal name for the genera and species of Amphioxus is *Cephalochorda*, the term referring to the extension of the primary backbone or *notochord* to the anterior extremity of the body; the family name is *Branchiostomidæ*. The amount of generic divergence exhibited by the members of this family is not great in the mass, but is of singular interest in detail. There are two principal genera—1. *Branchiostoma* Costa, having paired sexual organs (gonadic pouches); 2. *Heteropleuron* Kirkaldy, with unilateral gonads. Of these, the former includes two subgenera, *Amphioxus* (s. str.) Yarrell and *Dolichorhynchus* Willey. The species belonging to the genus *Heteropleuron* are divided among the three subgenera *Paramphioxus* Haeckel, *Epigonichthys* Peters, and *Asymmetron* Andrews. The generic characters are based upon definite modifications of form which affect the entire facies of the animals, while the specific diagnoses depend upon minor characters, such as the number of *myotomes* or muscle-segments.

Habits and Distribution.—With regard to its habits, all that need be said here is that while Amphioxus is an expert swimmer when occasion requires, yet it spends most of its time burrowing in the sand, in which, when at rest, it lies buried with head protruding and mouth wide agape. Its food consists of microscopic organisms and organic particles; these are drawn into the mouth together with currents of water induced by the action of the vibratile cilia which are abundant along special tracts on the sides and roof of the vestibule of the mouth and in the walls of the perforated pharynx ("ciliary ingestion"). Amphioxus favours a littoral habitat, and rarely if ever descends below the 50-fathom line. Species occur in all seas of the temperate, tropical, and subtropical zones. The European species, *A. lanceolatus*, is found in the Black and Mediterranean Seas, and on the coasts of France, Great Britain, and Scandinavia, while a closely allied species or sub-species, *A. caribæus*, frequents the Caribbean region from Chesapeake to La Plata. *A. californiensis* occurs on the coast of California, and *A. belcheri* extends its area of distribution from Queensland through Singapore to Japan. A recently described species, *Dolichorhynchus indicus*, characterized by the great length of the preoral lobe or snout, has been dredged in the Indian Ocean. *Paramphioxus bassanus* occurs on the coast of Australia from Port Phillip to Port Jackson; *P. cingalensis* at Ceylon. *Epigonichthys cultellus* (Fig. 1) inhabits Torres Strait, and has also been found at Ternate. *Asymmetron lucayanum* is the Bahaman representative of the family, with a sub-species, *A. caudatum*, in the South Pacific from New Guinea to the Loyalty Islands. The Peruvian species, *Branchiostoma elongatum*, with nearly 80 myotomes, cannot at present be assigned to its proper sub-genus.

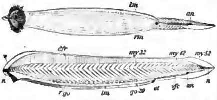


Fig. 1.—*Epigonichthys cultellus* from below and from the left side. (Slightly altered from Kirkaldy.) *rm* and *lm*, right and left metapleur; *at*, atriopore; *an*, anus; *e*, "eyespot" at anterior end of neurochord projecting beyond the myotomes (*my*); *n*, notochord; *rgo*, gonads of right side only showing through by transparency; *go20*, the last gonad; *dfr*, dorsal fin with fin-chambers and fin-rays; *vfc*, ventral fin-chambers.

External Form.—The following description, unless otherwise stated, refers to *A. lanceolatus*, which has been already figured in side view, in section, and in dissection in the article VERTEBRATA (*Ency. Brit.* vol. xxiv.). Amphioxus is a small fish-like creature attaining a maximum length of about 3 inches, semi-transparent in appearance, showing iridescent play of colour. The body is narrow, laterally compressed and pointed at both ends. The main musculature can be seen through the thin skin to be divided into about sixty pairs of muscle-segments (myotomes) by means of comma-shaped dissepiments, the *myocommas*, which stretch between the skin and the central skeletal axis of the body. These myotomes enable it to swim rapidly with characteristic serpentine undulations of the body, the movements being effected by the alternate contraction and relaxation of the longitudinal muscles on both sides. Apparently correlated with this peculiar locomotion is the anatomical fact of the alternation of the myotomes on the two sides. Symmetrical at their first appearance in the embryo, the *somites* (from which the myotomes are derived) early undergo a certain distortion, the effect of which is to carry the somites of the left side forwards through the length of one half segment. For example, the twenty-seventh myotome of the left side is placed opposite to the twenty-sixth myocomma of the right side. The back of the body is occupied by a crest, called the *dorsal fin*, consisting of a hollow ridge, the cavity of which is divided into about 250 compartments or *fin-chambers*, into each of which, with the exception of those near the anterior and posterior ends of the body, projects a stout pillar composed of characteristic laminar tissue, the *fin-ray*. The dorsal crest is continued round both extremities, becoming expanded to form the *rostral fin* in front and the *caudal fin* behind. Even in external view, careful inspection will show that the body is divisible into four regions, namely, cephalic, atrial, abdominal, and caudal. The *cephalic region* includes the rostrum or preoral lobe and the mouth. As already stated, the notochord extends beyond the mouth to the tip of the rostrum. The mouth consists of two portions, an outer *vestibule* and an inner *apertura oris*; the latter is surrounded by a sphincter muscle, which forms the so-called *velum*. The vestibule of the mouth is the space bounded by the *oral hood*; this arises by secondary down-growth of lip-like folds over the true oral aperture, and is provided with a fringe of *tentacular cirri*, each of which is supported by a solid skeletal axis. The oral hood with its cirri has a special nerve-supply and musculature by which the cirri can be either spread out, or bent inwards so that those of one side may interdigitate with those of the other, thus completely closing the entrance to the mouth. The velum is also provided with a circlet of twelve tentacles (in some species sixteen) which hang backwards into the pharynx; these are the *velar tentacles*. The *atrial region* extends from the mouth over about two-thirds of the length of the body, terminating at a large median ventral aperture, the *atriopore*; this is the excurrent orifice for the respiratory current of water and also serves for the evacuation of the generative products. This region is really the *branchiogenital region*, although the fact is not apparent in external view. The ventral side of the body in the atrial region is broad and convex, so that the body presents the appearance of a spherical triangle in transverse section, the apex being formed by the dorsal fin and the angles bordered by two hollow folds, the *metapleural folds*, each of which contains a continuous longitudinal lymph-space, the *metapleural canal*. In the genus *Branchiostoma* the metapleural folds terminate symmetrically shortly behind the atriopore, but in *Heteropleuron* the right metapleur passes uninterruptedly into the median crest of the *ventral fin* (Fig. 1). In this connexion it may also be mentioned that in all cases the right half of the oral hood is directly continuous with the rostral fin (Fig. 2).

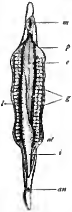


Fig. 2.—*Amphioxus lanceolatus* laid open ventrally. (After Rathke, slightly altered.) *m*, mouth appearing as an elongated slit when relaxed (as in the lamprey); *p*, perforated pharynx; *e*, endostyle; *g*, gonads; *l*, liver; *at*, level of atriopore; *i*, intestine; *an*, anus. In this species the atrium is produced as an asymmetrical blind pouch behind the atriopore as far as the anus.

The *abdominal region* comprises a short stretch of body between atriopore and anus, the termination of the alimentary canal. It is characterized by the presence of a special development of the *lophioderm* or median fin-system, namely, the *ventral fin*, which is composed of two portions, a lower keel-like portion, which underlies an upper chambered portion, each chamber containing typically a pair of gelatinous fin-rays. Finally, the *caudal region* comprises the post-anal division of the trunk. The keel of the ventral fin is continued past the anus into the expanded caudal fin, and so it happens that the anal opening is displaced from the middle line to the left side of the fin. In *Asymmetron* the caudal region is remarkable for the curious elongation of the notochord, which is produced far beyond the last of the myotomes.

Alimentary, Respiratory, and Excretory Systems.—Although the function of the two latter systems of organs is the purification of the blood, they are not usually considered together, and it is therefore the more remarkable that their close association in *Amphioxus* renders it necessary to treat them in common. The *alimentary canal* is a perfectly straight tube lined throughout by ciliated epithelium. As food particles pass in through the mouth they become enveloped in a slimy substance (secreted by the *endostyle*) and conveyed down the gut by the action of the vibratile cilia as a continuous food-rope, the peristaltic movements of the gut-wall being very feeble. The first part of the alimentary canal consists of the *pharynx* or *branchial sac*, the side walls of which are perforated by upwards of sixty pairs of elongated slits, the *gill-clefts*. Each primary gill-cleft becomes divided into two by a *tongue-bar* which grows down secondarily from the upper wall of the cleft and fuses with the ventral wall. New clefts continue to form at the posterior end of the pharynx during the adult life of the animal. The gill-clefts open directly from the cavity of the pharynx into that of the *atrium* and so give egress to the respiratory current which enters the mouth with the food (Fig. 2). The atrium or atrial chamber is a peripharyngeal cavity of secondary origin effecting the enclosure of the gill-clefts, which in the larva opened directly to the exterior. The atrium is thus analogous to the opercular cavity of fishes and tadpoles, and, as stated above, remains in communication with the exterior by means of the atriopore. The primary and secondary bars which separate and divide the successive gill-clefts from one another are traversed by blood-vessels which run from a simple tubular contractile ventral branchial vessel along the bars into a dorsal aorta. The ventral branchial vessel lies below the *hypobranchial groove* or *endostyle*, and is the representative of a heart. As water for respiration streams through the clefts, gaseous interchange takes place between the circulating colourless blood and the percolating water. The pharynx projects freely into the atrium; it is surrounded at the sides and below by the continuous atrial cavity, but dorsally it is held in position in two ways. Firstly, its dorsal wall (which is grooved to form the *hyperpharyngeal groove*) is closely adherent to the sheath of the notochord; and secondly, the pharynx is attached through the intermediation of the primary bars. These are suspended to the muscular body-wall by a double membrane, called the *ligamentum denticulatum*, which forms at once the roof of the atrial chamber and the floor of a persistent portion of the original body-cavity or *cœlom* (the *dorsal cœlomic canal* on each side of the pharynx). The *ligamentum denticulatum* is thus lined on one side by the epiblastic *atrial epithelium*, and on the other by mesoblastic *cœlomic epithelium*. Now this ligament is inserted into the primary bars some distance below the upper limits of the gill-clefts, and it therefore follows that, corresponding with each tongue-bar, the atrial cavity is produced upwards beyond the insertion of the ligament into a series of bags or pockets, which may be called the *atrial pouches*. At the top of each of these pouches there is a minute orifice, the aperture of a small tubule lying above each pouch in the dorsal cœlom. These tubules are the excretory tubules or *nephridia*. They communicate with the cœlom by several openings or *nephrostomes*, and with the atrium by a single opening in each case, the *nephridiopore*. It is important to emphasize the fact that in Amphioxus the excretory tubules are coextensive with the gill-clefts. The perforated pharynx terminates some distance in front of the atriopore. At the level of its posterior end a pair of funnel-shaped pouches of the atrium are produced forwards into the dorsal cœlom. These are the *atrio-cœlomic funnels* or *brown funnels*, so called on account of the characteristic pigmentation of their walls. There are reasons for supposing that these funnels are vestiges of an ancient excretory system, which has given way by substitution to the excretory tubules described above. In the same region of the body, namely, close behind the pharynx, a large diverticulum is given off from the ventral side of the gut. This is the *hepatic cæcum* (Fig. 2, *l*), which is quite median at its first origin, but, as it grows in length, comes to lie against the right wall of the pharynx. Although within the atrial cavity, it is separated from the latter by a narrow cœlomic space, bounded towards the atrium by cœlomic and atrial epithelium. No food passes into the hepatic cæcum, which has been definitely shown on embryological and physiological grounds to be the simplest persistent form of the vertebrate liver.

Nervous System.—As has been already indicated, a solid subcylindrical elastic rod, the *notochord*, surrounded by a sheath of laminar connective tissue, the *chordal sheath*, lies above the alimentary canal in contact with its dorsal wall, and extends beyond it both in front and behind to the obtusely pointed extremities of the body. This notochord represents the persistent primordial skeletal axis which, in the higher Craniota (though not so in the lower), gives way by substitution to the segmented vertebral column. Immediately above the notochord there lies another subcylindrical chord, also surrounded by a sheath of connective tissue. This chord is neither elastic nor solid, but consists of nerve tissue, fibres, and ganglion cells, surrounding a small central canal. For the sake of uniformity in nomenclature this nerve chord may be called the *neurochord*. It is the central nervous system, and contains within itself the elements of the brain and spinal marrow of higher forms. The neurochord tapers towards its posterior end, where it is coextensive with the notochord, but ends abruptly in front, some distance behind the tip of the snout. The neurochord attains its greatest thickness not at its anterior end but some way behind this region; but the central canal dilates at the anterior extremity to form a thin-walled *cerebral vesicle*, in the front wall of which there is an aggregation of dark pigment cells constituting an *eye-spot*, visible through the transparent skin (Fig. 1). There are two pairs of specialized *cerebral nerves* innervating the præoral lobe, and provided with peripheral ganglia placed near the termination of the smaller branches. Corresponding with each pair of myotomes, and subject to the same alternation, two pairs of *spinal nerves* arise from the neurochord, namely, a right and left pair of compact dorsal sensory roots without ganglionic enlargement, and a right and left pair of ventral motor roots composed of loose fibres issuing separately from the neurochord and passing directly to their termination on the muscle-plates of the myotomes. The first dorsal spinal nerve coincides in position with the myocomma which separates the first myotome from the second on each side, and thereafter the successive dorsal roots pass through the substance of the myocommata on their way to the skin; they are therefore *septal* or intersegmental in position. The ventral roots, on the contrary, are *myal* or segmental in position. In addition to the cerebral eye-spot there are large numbers of minute black pigmented bodies beside and below the central canal of the neurochord, commencing from the level of the third myotome. It has been determined that these bodies are of the nature of eyes (*Becheraugen*, Hesse), each consisting of two cells, a cup-shaped *pigment cell* and a triangular *retinal cell*. These may be called the *spinal eyes*, and it is said that they are disposed in such a way as to receive illumination preferentially from the right side, although this fact has no relation with the side upon which *Amphioxus* may lie upon the sand. When kept in captivity the animal often lies upon one side on the surface of the sand, but on either side indifferently. Over the cerebral eye there is a small orifice placed to the left of the base of the cephalic fin, leading into a pit which extends from the surface of the body to the surface of the cerebral vesicle; this is known as Kölliker's *olfactory pit*.

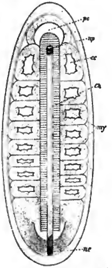


FIG. 2.—Diagram of embryo of *Amphioxus* seen from above in optical section. (Adapted from Hatschek.) *pc*, præchordal head-cavity of embryo; *cc*, collar-cavity (first somite); *my*, mesodermic somites (myocœlomic or archenteric pouches); *ch*, notochord with the neural tube (neurochord) lying upon it; *np*, anterior neuropore; *ne*, position of posterior neurenteric canal.

Reproductive System.—The sexes are separate, and the male or female gonads, which are exactly similar in outward appearance, occur as a series of gonadic pouches projecting into the atrial cavity at the base of the myotomes (Fig. 2). At the breeding season the walls of the pouches burst and the sexual elements pass into the atrium, whence they are discharged through the atriopore into the water, where fertilization takes place.

Development.—The development of *Amphioxus* possesses many features of interest, and cannot fail to retain its importance as an introduction to the study of embryology. The four principal phases in the development are: (1) Blastula, (2) Gastrula, (3) Flagellate Embryo, (4) Larva. The segmentation or cleavage of the ovum which follows upon fertilization terminates in the achievement of the *blastula* form, a minute sphere of cells surrounding a central cavity. Then follows the phenomenon of gastrulation, by which one-half of the blastula is invaginated into the other, so as to obliterate the segmentation cavity. The embryo now consists of two layers of cells, *epiblast* and *hypoblast*, surrounding a cavity, the *archenteron*, which opens to the exterior by the orifice of invagination or *blastopore*. One important fact should be noted with regard to the *gastrula*, in which it seems to differ from the gastrulæ of invertebrate. After invagination is completed, the embryo begins to elongate, the blastopore becomes narrower, and the dorsal wall of the gastrula loses its convexity and becomes flattened to form the *dorsal plate*, the outer layer of which is the primordium of the neurochord, and the inner layer the primordium of the notochord. While still within the egg-membrane the epiblastic cells become flagellated, and the gastrula rotates within the membrane. About the eighth hour after commencement of development the membrane ruptures and the oval embryo escapes, swimming by means of its flagella at the surface of the sea for another twenty-four hours, during which the principal organs are laid down, although the mouth does not open until the close of this period. The primordium of the neurochord (neural or *medullary plate*) referred to above becomes closed in from the surface by the overgrowth of surrounding epiblast, and its edges also bend up, meet, and finally fuse to form a tube, the medullary or neural tube. An important fact to note is that the blastopore is included in this overgrowth of epiblast, so that the neural tube remains for some time in open communication with the archenteron by means of a posterior *neurenteric canal*. It is still longer before the neural tube completes its closure in front, exhibiting a small orifice at the surface, the anterior *neuropore*. It is thus possible that the neurenteric canal is due to the conjunction of a posterior neuropore with the blastopore, *i.e.*, it is a complex and not a simple structure. Paired archenteric pouches meanwhile appear at the sides of the axial notochordal tract, the *mesoblastic somites*. The first of these differs in several respects from those which succeed, and has been called the *collar cavity* (MacBride). In front of the latter there remains a portion of the archenteron, which becomes constricted off as the *head cavity*. This becomes divided into two, the right half forming the cavity of the rostrum, while the left acquires an opening to the exterior, and forms the *præoral pit* of the larva, which subsequently gives rise to special ciliated tracts in the vestibule of the mouth mentioned above. The larval period commences at about the thirty-sixth hour with the perforation of the mouth, first gill-cleft, and anus. The larva is curiously asymmetrical, as many as fourteen gill-clefts appearing in an unpaired series on the right side, while the mouth is a large orifice on the left side, the anus being median. The adult form is achieved by metamorphosis, which cannot be further described here. One point must not be omitted, namely, the homogeny of the *endostyle* of A. and the *thyroid gland* of Craniota.

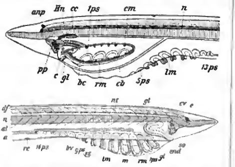


FIG. 4.—Anterior region of two pelagic larvæ of *A. lanceolatus* obtained by the tow-net in 8-10 fathoms, showing the asymmetry of the large lateral sinistral mouth with its ciliated margin *cm* and the dextral series of simple primary gill-slits (1*ps*–14*ps*). The larvæ swim normally like the adult or suspend themselves by their flagella (not shown in the figures) vertically in mid-water. There is nothing in their mode of life which will afford an explanation of the asymmetry which is a developmental phenomenon. *Lettering of upper figure.*—*anp*, anterior neural pore; *bc*, rudiment of buccal skeleton; *c*, cilia; *cb*, ciliated band; *cc*, ciliated groove; *cm*, cilia at margin of mouth; *gl*, external opening of club-shaped gland; *Hn*, Hatschek's nephridium; *lm*, left metapleur; *n*, notochord; *pp*, præoral pit; *ps*, primary gill-slits, 1, 5, and 13; *rm*, right metapleur showing through. *Lettering of lower figure.*—*a*, atrium; *al*, alimentary canal; *bv*, blood-vessel; *cv*, cerebral vesicle; *df*, dorsal section of myocœl (= fin-spaces); *e*, "eyespot"; *end*, endostyle; *gl*, club-shaped gland; *lm*, edge of left metapleur; *m*, lower edge of mouth; *n*, notochord; *nt*, pigmented nerve tube; *ps*, primary gill-slits, 1, 9, and 14; *re*, renal cells on atrial floor; *rm*, edge of right metapleur; *so*, sense organ opening into præoral pit; *ss*, thickenings, the rudiments of the row of secondary gill-slits.

REFERENCES.—BOVERI. "Die Nierencanälchen des *Amphioxus*," *Zool. Jahrb. Anat.* v. 1892, p. 429.—FELIX. "Beiträge zur Entwickelungsgeschichte der Salmoniden," *Anat. Hefte Arb.* viii. 1897; *Amphioxus*, p. 333.—GARBOWSKI. "*Amphioxus* als Grundlage der Mesodermtheorie," *Anat. Anz.* xiv. 1898, p. 473.—HESSE. "Die Sehorgane des *Amphioxus*," *Zeitschr. wiss. Zool.* lxiii. 1898, p. 456.—KIRKALDY. "A Revision of the Genera and Species of the Branchiostomidæ," *Quart. J. Micr. Sci.* xxxvii. 1895, p. 303.—LANKESTER. "Contributions to the Knowledge of *Amphioxus lanceolatus* (Yarrell)," *op. cit.*, xxix. 1889, p. 365.—LWOFF. "Die Bildung der primären Keimblätter und die Entstehung der Chorda und des Mesoderms bei den Wirbelthieren," *Bull. Soc. Moscow*, 1894.—MACBRIDE. "The early Development of *Amphioxus*," *Quart. J. Micr. Sci.* xl. 1897, p. 589, and xliii. 1900.—MORGAN and HAZEN. "The Gastrulation of *Amphioxus*," *J. Morphol.* xvi. 1900, p. 569.—SAMMASSA. "Studien über den Einfluss des Dotters auf die Gastrulation und die Bildung der primären Keimblätter der Wirbelthiere: iv. *Amphioxus*," *Arch. Entwickmech.* vii. 1898, p. 1.—SCHNEIDER. "Einiges über Resorption und Excretion bei *Amphioxus lanceolatus*," *Anat. Anz.* xvi. 1900, p. 601.—SOBOTTA. "Die Reifung und Befruchtung des Eies von *Amphioxus lanceolatus*," *Arch. mikr. Anat.* l. 1897, p. 15.—WEISS. "Excretory tubules in *Amphioxus lanceolatus*," *Quart. J. Micr. Sci.* xxxi. 1890, p. 489.—WILLEY. *Amphioxus and the Ancestry of the Vertebrates*, 1894; "Remarks on some recent Work on the Protochorda," *Quart. J. Micr. Sci.* xlii. 1899, p. 223; "Dolichorhynchus indicus," *ibid.*, 1901.—BENHAM. "Heteropleuron of New Zealand," *ibid.*, 1901.—BURCHARDT. "Finer Anatomy of Amphioxus," with bibliography, *Jena Zeitschr.* xxxiv. 1900, p. 719.

(A. W.*)

AMPTHILL, ODO WILLIAM LEOPOLD RUSSELL, 1st BARON (1829-1884), British diplomatist and ambassador, was born in Florence on the 20th of February 1829. He was the son of Major-General Lord George William Russell, by Elizabeth Ann, niece of the marquess of Hastings, who was governor-general during the final struggle with the Mahrattas. His education, like that of his two brothers—Hastings, who became eventually ninth duke of Bedford, and Arthur, who sat for a generation in the House of Commons as member for Tavistock—was carried on entirely at home, under the general direction of his mother, whose beauty was celebrated by Byron in *Beppo*. Lady William Russell was as strong-willed as she was beautiful, and certainly deserved to be described as she was by Disraeli, who said in conversation, "I think she is the most fortunate woman in England, for she has the three nicest sons." If it had not been for her strong will it is as likely as not that all the three would have gone through the usual mill of a public school, and have lost half their very peculiar charm. In March 1849 Odo was appointed by Lord Malmesbury attaché at Vienna. From 1850 to 1852 he was temporarily employed in the Foreign Office, whence he passed to Paris. He remained there, however, only about two months, when he was transferred to Vienna. In 1853 he became second paid attaché at Paris, and in August 1854 he was transferred as first paid attaché to Constantinople, where he served under Lord Stratford de Redcliffe. He had charge of the embassy during his chief's two visits to the Crimea in 1855, but left the east to work under Lord Napier at Washington in 1857. In the following year he became secretary of legation at Florence, but was detached from that place to reside in Rome, where he remained for twelve years, till August 1870. During all that period he was the real though unofficial representative of England at the Vatican, and his consummate tact enabled him to do all, and more than all, that an ordinary man could have done in a stronger position. A reference, however, to his evidence before a committee of the House of Commons in 1871 will make it clear to any unprejudiced reader that those were right who, during the early 'fifties, urged so strongly the importance of having a duly accredited agent at the Papal Court. The line taken by him during the Vatican Council has been criticized, but no fault can justly be found with it. Abreast as he was of the best thought of his time—the brother of Arthur Russell, who, more perhaps than any other man, was its most ideal representative in London society—he sympathized strongly with the views of those who laboured to prevent the extreme partisans of papal infallibility from having everything their own way. But in his capacity of clear-headed observer, whose business it was to reflect the actual truth upon the mind of his Government, he was obliged to make it quite clear that they had no chance whatever, and in conversing with those whose opinions were quite unlike his own, such as Cardinal Manning, he seems to have shown that he had no illusions about the result of the long debate. In 1868 Odo Russell married Lady Emily Theresa Villiers, the daughter of Lord Clarendon. In 1870 he was appointed assistant under-secretary at the Foreign Office, and in November of that year was sent on a special mission to the headquarters of the German army, where he remained till 1871. A little later in the same year he received the well-deserved reward of his labours by being made ambassador at Berlin.

During the months he passed at the Foreign Office he was examined before the committee of the House of Commons, already alluded to, and had an opportunity of stating very distinctly in public some of his views with regard to his profession. It was before the same committee that he said that "if you could only organize diplomacy properly, you would create a body of men who might influence the destinies of mankind and ensure the peace of the world." In these words we have the key to the thought and habitual action of one of the best and wisest public servants of the time. If more people could be converted to his views, the diplomatic service sufficiently increased, the means of getting adequate information from abroad improved, and that information properly digested, the cost of some regiments and not a few ironclads might be saved.

Lord Ampthill remained at Berlin, with only brief intervals of absence, from 16th October 1871 till his death at Potsdam on the 25th August 1884. He was third plenipotentiary at the Berlin Congress, and is generally credited with having prevented, by his tact and good sense, the British prime minister from making a speech in French, which he knew very imperfectly and pronounced abominably. In 1874 Odo Russell received a patent of precedence raising him to the rank of a duke's son, and after the Congress of Berlin he was offered a peerage by the Conservative Government. This he naturally declined, but accepted the honour when it was offered by the Liberals. He became a privy councillor in 1872 and was made a G.C.B. somewhat later. At the conference about the Greek frontier, which followed the Congress of Berlin, he was the only British representative. During all his long sojourn in the Prussian capital, he did everything that in him lay to bring about close and friendly relations between Great Britain and Germany. He kept on the best of terms with Bismarck, carefully avoiding everything that could give any cause of offence to that most jealous and most unscrupulous minister, whom he, however, did not hesitate to withstand when his unscrupulousness went the length of deliberately attempting to deceive. What might have happened if Lord Ampthill's life had been prolonged, and the Emperor Frederick had come to the throne at about the period of life at which it would have been natural for him to do so, in the first half of the 'seventies, it is impossible to say. The death in 1888 of the Emperor Frederick was, as has been truly said, "Not the death of a man but of a generation." (M. G. D.)

Amraoti, or Umrawattee, a town and district of India, in Berar or the Haidarabad Assigned Districts, under British administration. The town is 1222 feet above the sea; the railway station is six miles from Badnera junction on the Great Indian Peninsula line. Population (1881), 23,550; (1891), 28,946, excluding 4709 in the civil station. Amraoti raw cotton is quoted on the Liverpool Exchange. There are 11 cotton presses with an out-turn of 70,000 bales; and a mill at Badnera, with 248 looms and 18,900 spindles, employing 1186 hands, which, in 1897-98, produced 5796 bales of twist and yarn, and 2442 bales of cloth. There are two high schools, with 354 pupils; and a school for European boys and girls, maintained by a Roman Catholic mission. The town has four printing-presses, one issuing a vernacular newspaper.

The district of AMRAOTI has an area of 2759 square miles; population (1881), 575,328; (1891), 655,645; (1901), 630,245, showing a decrease of 4 per cent. The land revenue and rates in 1897-98 were Rs.17,01,357, the incidence of assessment being R.1:1:4 per acre; the cultivated area was 1,414,361 acres, of which 8745 are irrigated from wells; the number of police was 623; the number of boys at school in 1896-97 was 14,065, being 27·5 per cent. of the male population of school-going age; the registered death-rate in 1897 was 60·5 per thousand. The district is crossed by the main line of the Great Indian Peninsula railway. In 1899-1900 it suffered severely from drought.

Amravati, a village of British India, in the Kistna district of the Madras Presidency. It is situated in 16° 34′ N. lat. and 80° 24′ E. long., on the right bank of the river Kistna, near the head of its delta. Here are, or rather were, the ruins of the finest Buddhist monument in India. It was a *stupa*, or "tope," built to enshrine a relic of Gautama Buddha. It is enthusiastically described by Hwen Thsang, the Chinese pilgrim, who visited it in 639. In the beginning of the 19th century elaborate excavations and drawings were made by Colin Mackenzie. The sculptures subsequently carried off by Sir Walter Elliot now line the great staircase of the British Museum, and are figured in Fergusson's *Tree and Serpent Worship* (1868). Further researches were conducted on behalf of the Government in 1877 and 1882, and the best of the remaining sculptures were taken to Madras. A handsome memoir by Dr James Burgess was published in 1887, as one of the volumes of the Archæological Survey of Southern India.

Amritsar (UMRITSUR), a city and district of British India, in the Lahore division of the Punjab. It has a station on the North-western railway 32 miles east of Lahore. Population (1881), 151,896; (1891), 136,766; (1901), 162,548, showing an increase of 19 per cent. Municipal income (1897-98), Rs.4,42,372; death-rate (1897), 36 per thousand. A Sikh college for university education was opened in 1897. The other public buildings include two churches, a town hall, and a hospital. There are also a municipal college; 5 high schools for boys; 3 secondary schools for girls; 17 printing presses, issuing 10 newspapers and periodicals; Hindu, Sikh, and Mahommedan literary institutions.

The area of the district of AMRITSAR is 1601 square miles; population (1881), 893,266; (1891), 992,697, showing an increase of 11 per cent., and an average density of 620 persons per square mile; (1901), 1,023,902, shewing an increase of 3 per cent. The land revenue and rates in 1897-98 amounted to Rs.12,44,644, the incidence of assessment being R.1 : 5 : 0 per acre; the cultivated area was 772,724 acres, of which 543,068 were irrigated, including 247,465 from government canals; the number of police was 852; the number of schools in 1896-97 was 395, attended by 15,376 boys, being 17·4 per cent. of the boys of school-going age; the death-rate in 1897 was 28 per thousand. The principal crops are wheat, pulse, maize, millet, with some cotton and sugar-cane. There are two factories for ginning and pressing cotton.

Amroha, a town of British India, in the Moradabad district of the North-west Provinces, is situated in 28° 54′ N. lat. and 78° 31′ E. long. It contains the tomb of Shaikh Saddu, and has been for many centuries a Mahommedan centre. It has a high school. In 1897-98 the municipal income was Rs.25,687. Population (1891), 35,230.

Amsterdam, the capital and one of the two chief commercial centres of the Netherlands, in the province of North Holland, on the Y inlet of the Zuyder Zee; connected by the Ymuiden Canal with the North Sea. The money market is of importance, and is the headquarters of companies formed to promote the cultivation of colonial produce. A central station has been erected (1888), a new theatre (1894), a new post office (1898), a music hall, a new exchange (1901), and an abattoir. To scientific and artistic institutions have been added a school of navigation (1879), a school of engineering (1879), a school for teachers (1878), a school of industrial art; the "Quellinus" (1880), a university (1877), which took the place of the Atheneum, a free university (1883), the State Museum (Ryksmuseum, 1876-85), in which are collected, from various other museums, pictures, drawings, prints, sculpture, and casts, and the Museum Suesso Lopez, for modern paintings (1895). The progress of navigation and commerce has been promoted by the construction of a canal to the North Sea (1876), with a depth of 30 to 33 feet; the Commercial or *Handels* dock; the railway, wood, and petroleum (1880-90) docks; the Merwede Canal, connecting the town with the great rivers (1893), and the new Entrepôt dock (1900). The tonnage of ships entering and clearing the port in 1870 was 808,042 tons (metric), which in 1899 had risen to 4,310,000 tons (16·6 per cent. of that of the whole kingdom). In 1899, 9988 ships of 15,680,000 tons passed through the North Sea Canal. In 1899, 2029 vessels entered with the following imports:—163 ship loads of timber, 142 of ore, 177 of coal and coke, 312 of piece goods, 34 of rice and other grain, 25 of petroleum, 4 of linseed, and the remaining 1172 of ballast and miscellaneous goods. Of late years Sumatra tobacco has ranked first among the exports of colonial produce; but tea, cocoa, and Peruvian bark (*cinchona*) are also important. The supply of tea for the Amsterdam market, which in 1888 amounted to 5,002,000 lb, had risen in 1897 to 10,738,225 lb; the supply of cinchona in 1889, 171,207 lb, had risen in 1897 to 580,722 lb. The value of Sumatra tobacco imported in 1865 was £3333; in 1896, £2,687,500. Since 1874 railways have been constructed connecting Amsterdam with Belgium (*viâ* Utrecht, Bois-le-Duc, and Maestricht) and with Prussia (*viâ* Hilversum and Zutphen). Regular steamers maintain communication with sixty-one places in the Netherlands. The tonnage of this inland navigation, carried in 80,000 vessels, amounted in 1899 to 4,310,000 cubic metres (the register ton is equal to 2·83 cubic metres). To the industries have been added of late years shipbuilding and the manufacture of machinery and stearine candles. The population in 1874 was 285,000; in 1890, 408,061; in 1900, increased by that of Neuwer Amstel (annexed in 1896; population, 25,000), 523,557, about 100,000 of whom are Roman Catholics and about 50,000 Jews.

See TER GOUW. *Amstelodamiana.* Amsterdam, 1873-74.—SEQUEIRA. *Amsterdam, Guide descriptive, historique et topographique.* Amsterdam, 1877.—TER GOUW. *Geschiedenis van Amsterdam.* Amsterdam, 1886.—KALFF. *Oud en Nieuw Amsterdam.* Amsterdam, 1880. (C. M. K.)

Amsterdam, a city of Montgomery county, New York, U.S.A., situated in 42° 57′ N. lat. and 74° 11′ W. long., on the north bank of Mohawk river, at an altitude of 277 feet. Its site is hilly and the plan is irregular. It is divided into seven wards. Two railways enter it, the New York Central and Hudson River, and the West Shore. It has an excellent water supply and good drainage. The population in 1880 was 9466, in 1890 it was 17,336, and in 1900 it was 20,929.

Amu-daria, a great river of Central Asia, tributary of Lake Aral (see OXUS), and also the name of a separate administrative division (*Amu-dariinskiy Otdyel*) of the Syr-daria province of Russian Turkestan. (See TURKESTAN, SYR-DARIA, and ARAL-CASPIAN REGION.)

Amur, an extensive province of Siberia, Russia in Asia, on the left bank of the Amur river, which was conceded to Russia by China by the treaties of 1857 and 1858. It includes the basins of the Oldoi, Zeya, and Bureya, left bank tributaries of the Amur, and has the provinces of Transbaikalia in the W., Yakutsk in the N., Maritime in the E., and Manchuria in the S.W. and S. Area, 172,848 sq. miles. Immense districts are quite uninhabited. All its north-western part is occupied by the High plateau, bordered by the Great Khingan border range, whose exact position in the region is not yet definitely settled. Next comes a belt of fertile high plains, inhabited mainly by Nonconformist emigrants from Russia, and limited on the east by the Little Khingan, or Dousse-alin, a picturesque well-wooded range, which stretches in a north-easterly direction from Kirin across Manchuria, is pierced by the Amur, and continues on its left bank, separating the Bureya from Amgun. To the east of it stretches in the same direction a belt of marshy lowlands, which includes also farther south the lower course of the Sungari. Frequent inundations, resulting from torrential rains occasioned by the monsoons, present great difficulties to the development of the belt. In the ranges which rise above the surface of the high plateau in the north-west, in the vicinity of the Stanovoi watershed, gold-mines of great richness are worked. Gold was also found in the fabulously rich mines of the Zheltuga (Manchuria) where a sort of free republic of Russian and Chinese miners was formed in 1880-82. Coal of inferior quality is known to exist on the Oldoi, Zeya, and Bureya. The Russians are represented by the Amur Cossacks, whose villages are situated at about 17 to 20 miles from each other along the whole course of the river (Albazin, Kumara, Ekaterino-Nikolskaya, and Mikhailo-Semenovskaya are the chief ones); by peasant immigrants, chiefly Nonconformists, who are the wealthiest part of the population; and by a floating population of workers in the mines. Some Chinese have remained in the province, and consider themselves under Chinese rule; Tungus (Orochons), Manegres, and Golds lead a nomadic life along the rivers, living by hunting and fishing. Steamers ply regularly along the Amur for 6½ months, from Khabarovsk to Sryetensk, on the Shilka (terminus of the Trans-Siberian Railway); but only light steamers having from 2 to 3 feet draught can navigate the upper Amur and Shilka. In the winter the frozen river is the usual highway. Rough roads and bridle-paths only are found in the interior. The great engineering difficulties in building a railway along the Amur induced the Russian Government to obtain from China permission to build a railway through Manchuria. For the navigation on the Amur there are now 112 steamers of 29,300 horse-power, and 152 barges of 37,000 tons. The Amur province has a continental climate, the yearly average at Blagovyeschensk (50° N. lat.) being 30° Fahr. (January −17°, July 70°). It experiences the influence of the monsoons, and has mostly cold north-west winds from October to March, while in July and August it receives torrential rains, resulting in a sudden and very considerable rise of water in the Amur and all its r.h. tributaries. The chief and in fact the only town of the province is Blagovyeschensk, but the chief centre of the administration of the Amur region is now Khabarovsk. The settled population in 1897 was 118,570 (51,975 women), of whom 31,515 lived in towns. (P. A. K.)

Anaconda, a city of Montana, U.S.A., the capital of Deer Lodge county, situated in the mountains on the west side of Deer Lodge Valley, in the south-western part of the state. It is entered by the Montana Central, a branch of the Great Northern, and the Butte, Anaconda and Pacific railways. Its chief industry is the smelting of copper ores, obtained from mines in the neighbourhood. The population in 1890 was 3975, and in 1900 it was 9453.

Anam, or Annam. See Cochin China.

Anamalai Hills, a range of mountains in Southern India, in the Coimbatore district of Madras, lying between 10° 13′ and 10° 31′ N. lat., and between 76° 52′ and 77° 23′ E. long., forming a portion of the Western Ghats, after this range has been broken by the Palghat Pass, south of the Nilgiris. They really consist of a forest-clad and grassy tableland, with summits rising above 8000 feet. Their geological formation is metamorphic gneiss, veined with felspar and quartz, and interspersed with reddish porphyrite. The lower slopes yield valuable teak and other timber; and some land has been taken up for coffee-planting. The only inhabitants are a few wild tribes, who live by hunting and collecting jungle produce.

Ananieff, a district town of Russia, government of Kherson, on Tiligul river, 118 miles N.W. of Odessa, 12 miles from Zherebkovo, a station of the South-Western railway. It has trade in corn and cattle. It was annexed to Russia in 1792. Population (1897), 16,713—Russians, Jews, and Moldavians.

Anantapur, a town and district of India, in the Madras presidency, situated in 14° 41′ N. lat. and 77° 39′ E. long. It has a station on the Madras railway, 62 miles S.E. from Bellary. Population (1891), 6994. The municipal income in 1897-98 was Rs.20,410. There is a municipal high school.

The district of Anantapur was constituted in 1882 out of the unwieldy district of Bellary. It has an area of 5725 square miles, and its population in 1891 was 708,549, being 134 persons per square mile; in 1901, 788,896, showing an increase of 8 per cent. The land revenue and rates were Rs.9,63,538, the incidence of assessment being R.0 : 12 : 5 per acre; the number of police was 702. In 1897-98, out of a total cultivated area of 1,428,404 acres, 169,655 were irrigated, including 34,723 from government canals; the principal crops are millet, rice, other food grains, pulse, oil-seeds, and cotton. There are three steam factories for pressing cotton. Two railways traverse the district. The number of schools in 1896-97 was 577, with 11,636 pupils; the proportion of boys at school to the population of school-going age being 19·5 per cent., and the proportion of girls 2 per cent. The registered death-rate in 1897 was 26·9 per thousand.

Anarchism, a theory of politics, according to which all forms of organized government, except the free commune, are objectionable, since the individual should be a law to himself; and a theory of economics, according to which land and capital ought to be the common property of society. There is also a propaganda of revolution by violence. The principal writers who treat of the theory of anarchy in its different aspects are Proudhon, Elisée Réclus, Herbert Spencer, Kropotkin, and Bakounine. In America, Mr Benjamin R. Tucker has published since 1882 a journal named *Liberty*, which is devoted to philosophical anarchism. In the congress of the International Working People's Association, at the Hague, September 1872, the followers of Bakounine separated themselves from those of Karl Marx. This was the definitive beginning of the anarchist propaganda. The Bakounine party organized the "Fédération Jurassienne," and established a paper at Geneva, *L'Avant Garde*. This journal was, in 1878, succeeded by *La Révolte*, founded by Réclus and Kropotkin. Revolutionary organizations of working men were also formed in France, Spain, Italy, Switzerland, Belgium, Germany, England, and the United States. Between 1882 and 1886, in France, Prince Kropotkin, Louise Michel, and others were imprisoned, and their journal suppressed. In England, Most, one of the German anarchist leaders, founded *Die Freiheit*, and, for defending in it the assassination of Alexander II. at St Petersburg, was sentenced to eighteen months' imprisonment with hard labour. After this he moved to the United States, and re-established his paper there in New York, in May 1886. During this period there were several anarchist congresses in the United States. In one at Albany, in 1878, the revolutionary element, led by Justus Schwab, broke away from the others; at Allegheny City, in 1879, again there was a rupture between the peaceful and the revolutionary sections. *The Voice of the People* at St Louis, the *Arbeiter Zeitung* at Chicago, and the *Anarchist* at Boston, were the organs of the revolutionary element. In 1883, at Pittsburg, a congress of twenty-eight delegates, representing twenty-two towns, drew up an address to the working men of America. The programme it proposed was as follows:—

First, Destruction of the existing class rule by all means, *i.e.* energetic, relentless, revolutionary, and international action.

Second, Establishment of a free society, based upon co-operative organization of production.

Third, Free exchange of equivalent products by and between the productive organizations, without commerce and profit-mongery

Fourth, Organization of education on a secular, scientific, and equal basis for both sexes.

Fifth, Equal rights for all, without distinction of sex or race.

Sixth, Regulation of all public affairs by free contracts between the autonomous (independent) communes and associations, resting on a federalistic basis.

This, together with an appeal to the working men to organize, was published in Chicago, November 1883, by a local committee of four, representing French, Bohemian, German, and English sections, the head of the last being August Spies, who was hanged in 1887 for participation in the Haymarket affair in Chicago, 4th May 1886. This affair was the culmination of a series of encounters between the Chicago working men and the police, which had covered several years. The meeting of 4th May was called by Spies and others to protest against the action of the police, by whom several working men had been killed in collisions growing out of the efforts to introduce the eight hours' day. The mayor of the city attended the meeting, but, finding it peaceful, went home. The meeting was subsequently entered by the police and commanded to disperse. A bomb was thrown, several policemen being killed and a number wounded. For this crime eight men were tried in one panel and condemned, seven—Spies, Parsons, Engel, Fischer, Fielden, Schwab, and Ling—to death, and one—Neebe—to imprisonment for fifteen years. The sentences on Fielden and Schwab were commuted by Governor Oglesby to imprisonment for life, on the recommendation of the presiding judge and the prosecuting attorney. Ling committed suicide in jail, and Spies, Parsons, Engel, and Fischer were hanged, 11th November 1887. On 26th June 1893 an unconditional pardon was granted the survivors, Fielden, Schwab, and Neebe, by Governor Altgeld. The reasons for the pardon were stated by the governor to be that, upon an examination of the records, he found that the jury had not been drawn in the usual manner, but by a special bailiff, who made his own selection, and had summoned a "prejudiced jury"; that the "state had never discovered who it was that threw the bomb which killed the policemen, and the evidence does not show any connexion whatever between the defendants and the man who did throw it," . . . or that this man "ever heard or read a word coming from the defendants, and consequently fails to show that he acted on any advice given by them." Judge Gary, the judge at the trial, published a defence of its procedure in the *Century Magazine*, vol. xxiii. p. 803.

There have been a number of outbreaks in recent years attributed to the propaganda of reform by revolution, like those in Spain and France in 1892, in which Ravachol was a prominent figure. In 1893, a bomb was exploded in the French Chamber of Deputies by Vaillant. The spirit of these men is well illustrated by the reply which Vaillant made to the judge who reproached him for endangering the lives of innocent men and women: "There can be no innocent bourgeois." In 1894 there was an explosion in a Parisian café, and another in a theatre at Barcelona. For the latter outrage six men were executed. President Carnot of the French Republic was assassinated by an Italian at Lyons in the same year. The Empress Elizabeth of Austria was assassinated in September 1898. These events led to the passage by the United States Legislature of a law, in 1894, to keep out foreign anarchists, and to deport any who might be found in the country, and also to the assemblage of an international conference in Rome, in 1898, to agree upon some plan for dealing with these revolutionists. It was proposed that their offences should no longer be classed as political, but as common-law crimes, and be made subject to extradition. The suppression of the revolutionary press and the international co-operation of the police were also suggested. The results of the conference were not, however, published; and the question of how to deal with the campaign against society fell for a while into abeyance. More recently the attempt made by the youth Sipido on the (then) Prince of Wales at Brussels in 1900 recalled attention to the subject. The acquittal of Sipido, and the failure of the Belgian Government to see that justice was done in an affair of such international importance, excited considerable feeling in England, and was the occasion of a strongly-worded note from the British to the Belgian Government. The murder of King Humbert of Italy in July 1900 renewed the outcry against Italian anarchists. But even greater horror and indignation were excited by the assassination of President M'Kinley by Czolgosz on 6th September 1901, at Buffalo, U.S.A. (H. D. L.*)

ANATOMY.

MODERN ASPECTS AND METHODS.

THE acceptance of the doctrine of evolution has wrought cardinal changes in the position of anatomy as a branch of biology. So long as differing species of animals were believed to be genetically independent, resemblances in structure could only be interpreted upon some transcendental hypothesis, and no intelligible explanation could be given of the changes in form and arrangement which take place in almost every part during the process of embryonic development, or of such common phenomena as those of variation. The doctrine of community of descent has made possible a philosophic theory of morphology, which unifies and renders intelligible the otherwise incoherent facts of descriptive anatomy, and has opened up new fields of research.

Phylogenetic tendencies.

The bent of the new Comparative Anatomy has been mainly genealogical. Assuming that resemblances in structure are due to community of descent, its progress has been stimulated by the endeavour to determine the phyla or genealogical trees of allied forms on the basis of a comparison of the sum-total of resemblances in structure and organization. For this purpose the elaboration of a complete anatomical ontology is necessary. The field of research in this direction has been widely cultivated by Professor Gegenbaur and his school. The method of embryology is useful as a supplement and check to the teachings of ontology. Every animal begins existence as an egg, a single cell, from which is derived by a gradual process of growth and differentiation the complete organic structure of the adult state. As the eggs of most metazoan animals are constructed on the same plan, and as with each successive stage of development the range of resemblance in detail becomes more and more restricted, it has been supposed that the embryology of each individual is a recapitulation of the stages of the ontology of its ancestral forms. This serves as an excellent working hypothesis for purposes of classification.

International nomenclature.

Anthropotomy, in Great Britain at least, has hitherto profited less than any other branch of anatomy by the development of a philosophical morphology. The majority of those who study the subject are interested in it only so far as it is a handmaid to practical medicine and surgery, and its teaching is chiefly conducted by those who regard it from the professional standpoint, and by whom, naturally, the morphological aspect is subordinated to the technical. Attempts to remodel the nomenclature so as to bring human and comparative anatomy into line have not hitherto been encouraged by those authorities who exercise dominant influence in directing anatomical examinations. The spirit of the age will doubtless in time prove too strong for this obscurantism. On the Continent an effort has been made, especially by German teachers, to frame a uniform system of anatomical nomenclature. The names adopted by the Congress at Basel are largely those used by the school of Gegenbaur, and are not in all respects satisfactory. In England and France this nomenclature has been adopted by a few teachers only, and is used in a very few text-books. (For the best illustrated exposition of the Basel nomenclature, see Spalteholz, *Hand Atlas der Anatomie*, Leipzig, 1896.)

The importance of the study of the human type as a ground-work for morphological investigation has been admitted by all who are competent to judge. The body of man has been scrutinized with the greatest minuteness by hundreds of workers, and knowledge of its details and of its variations is far more extensive and more accurate than that of the body of any other animal.

Methods.

The methods of anatomical study are of two sorts—those whereby the structures are unravelled as far as it is possible to discriminate them by the naked eye, and those whereby the finer texture of the tissues is displayed and examined by the aid of the microscope. The procedures for either microscopic or macroscopic study are twofold—dissection and the cutting of sections. The former is the art of separating the component parts, and of rendering them available for study by the removal of the connective tissues and fat which envelop them, while by the latter the relative anatomy of the parts can be best exhibited. Macroscopic sections are made of the whole body or limb, by freezing and cutting the sections with a fine saw, or by hardening the parts by the injection of formalin, and cutting with a large and sharp knife (Fig. 1). The topography of regions can be most satisfactorily made out by the examination and comparison of successive sections made at short distances from each other. Sections for microscopic examination are most easily made of small parts of organs or whole organs hardened and embedded in some supporting material, such as paraffin wax or celloidin. These are cut into transparent films by means of a section-cutter, various patterns of which are in use. The best of these have an adjustment by means of which the sections can be cut of any required thickness, and the successive sections are preserved in the order in which they are cut. (The works of Braune, Rüdinger, and Symington give excellent plates of macroscopic sections of the body.) In preparing parts for dissection, it is of advantage that the tubular systems should be filled with some injected material, such as paint, wax, or starch. (Details of the modern methods in use are given by Gronroos, *Anat. Anzeiger*, 1898.) Microscopic sections are usually stained with certain soluble pigments, such as carmine, logwood, or eosin, which have the property of differentiating special tissues, such as protoplasm, cartilage, muscle, &c., colouring some and leaving others unstained. In modern anatomical technology, the number of such stains in use is large. (These methods of preparation are described in the text-books of histology by Schäfer, Stirling, Bolles Lee, &c.)

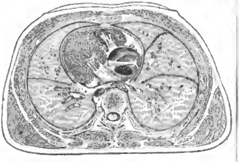


FIG. 1.—Section through the thorax on the level of the nipple, showing the position of the heart and lungs. (Merkel.)

In recent years, great progress has been made in the knowledge of the details of human structure. Many parts, such as the convolutions of the brain, the folds of the intestine, &c., formerly supposed to be indefinitely variable as if they were arranged at haphazard, have been shewn to be built up, even in their most minute details, in a definite manner capable of formulated description; indeed, it is probable that no structure is so completely variable that its different conditions are incapable of reduction to law. (Of modern text-books, those of Bardeleben and Gegenbaur in German, of Poirier and Testut in French, are the best; English text-books, such as Gray, Morris and Gerrish are excellent from the descriptive side, but almost completely ignore morphology. Quain's work in its latest edition is of the nature of a compromise between the morphological and the descriptive.)

ULTIMATE ANALYSIS OF THE BODY.

Cells.

The human body ultimately consists of *form-elements* of three sorts—cells, intercellular substance, and fibres. In its earliest form the whole organism was a single cell, and the first processes of growth consist in the multiplication of cells by division. A cell is not a homogeneous speck of protoplasm, but is a specialized structure exhibiting a comparatively complex organization (Fig. 2). The chief mass of the cell substance consists of a *cytomiton*, or network of protoplasmic threads, each of which often contains granules of some substance derived from the metabolism of protoplasm, the meshes of which are filled with a more fluid material or enchylema. The nucleus also is complex and enclosed by an apparently structureless limiting membrane, within which is a network of at least two kinds of material. One portion is capable of being stained by carmine, and on that account is called *chromatin*. The other part of the *karyomiton* or nuclear net is incapable of being stained. Although

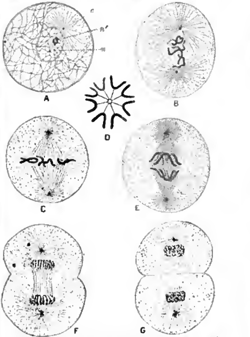


FIG. 2.—The cell and its process of division. A, Cell showing the network of spongioplasm; c, centrosome; n, nucleus; n', nucleolus. B, First stage of division formation of chromatin wreath. C, Monaster stage with spindle and centrosomes at the poles. D, Chromatin star of this stage, seen from above. E, Formation of diaster. F, The beginning of division and of the reconstruction of the nuclei. G, Stage of division nearly completed.

apparently casual in its form of meshwork, there is reason to believe that there are definite architectural laws according to which the chromatin filament is arranged, and some of these peculiarities in arrangement become obvious when a cell is about to divide (see *Ency. Brit.* vol. xx. pp. 416-417). In that condition the nuclear membrane disappears, and the chromatin filament forms a wreath through which a spindle of achromatin passes, at each pole of which a definite achromatic mass or centrosome accumulates, surrounded by a series of rays of achromatin. The equatorial chromatic wreath resolves itself into loops arranged with their closed ends directed inwards towards a central point and their free ends outwards. These loops undergo horizontal cleavage from looped to free end, and the looped ends pass along the surface of the spindle towards pole and antipole. When thus separated, the cell becomes mesially constricted and ultimately divides. Cells may be of very varied shapes and differ among themselves in structure and function, as noted in subsequent sections of this article; but they are, in the respects above enumerated, built on a common plan. (For further particulars on cell-structure, see the text-books of histology above quoted, also the text-books of embryology of v. Kolliker, Minot, Kollmann, and Hertwig, and the several numbers of Carnoy's periodical *La Cellule.*)

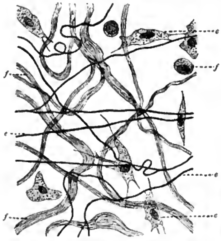


FIG. 3.—Connective tissue, showing cells, fibres, and ground-substance. × 350. (Szymonowicz.) *c*, cell; *e*, elastic fibril; *f*, white fibril.

Inter-cellular substance.

The structureless material known as intercellular ground-substance varies in quantity in different tissues of the body, being sometimes only a slight cement layer joining contiguous cells, sometimes a copious substance in which cells are embedded. In all cases it has originated either by the exudation of material from cells or by the transformation of the periphery of a cell. Chemically, it is made up of some protoplasm-derivate, which varies in its nature in different tissues.

Fibres.

Fibres are not, strictly speaking, a single category comparable with cells. A fibre is an elongated, thread-like form-element, but fibres of different kinds have different morphological values. Some, such as nerve fibres, are elongated processes of cells, made of the same material as the cell-body, and often enclosed in a tubular sheath of the nature of an investing layer of intercellular material. Others, such as muscle fibres, are elongated cell-bodies whose cytomiton is so arranged that the contraction of the protoplasm of the cell can only act in one direction, shortening the fibre along its long axis. Fibres in connective tissue (Fig. 3) are for the most part of a different kind, consisting of elongated threads of intercellular substance differentiated from the material around them by virtue of the deposit of rows of granules or linear masses of some particular protoplasm-derivate. The nature of these granules determines the kind of fibre formed, and they are in this way marked off from the formless ground-substance with which they are surrounded, being usually separate from the processes of the branched connective tissue cells. It is possible, however, that some fibres in areolar tissue may be derived from elongated cell processes which have lost their connexion with a cell-body.

HISTOLOGY.

Epithelial tissue.

Form-elements when aggregated into continuous masses make up tissues, which may be classified according to their embryological history, their position, and their properties into four great classes—*epithelial*, *nervous*, *muscular*, and *connective*. Epithelial tissue (see *Ency. Brit.* vol. i. p. 847 and xii. 5) is the lineal descendant of the superficial and the deepest of the three primary laminæ of the embryo (*Ib.* vol. xx. p. 418). It is usually disposed as the boundary layer of a free surface, preventing the leakage of the lymph or nutritive fluid in the underlying intercellular spaces. The amount of intercellular substance in epithelium is minimal, usually only represented by a layer of cement between contiguous cells. Epithelial tissues differ widely among themselves in properties according to the situation which they occupy; with these physiological variations are correlated morphological differences in the forms and structure of the cells.

The conditions determining divergence are degree of superficial pressure, of lateral tension, the nature of the material in contact with their free surfaces, and their degree of nutrition. When stratified in comparatively thick masses, as in the epidermis, the intermediate layers consist of *prickle cells* (see vol. i. p. 897), whose surfaces are beset with processes which join similar processes of other cells, leaving between them lymph spaces for nutrition. In some such cases, it appears from the observation of Cleland and Thomson that the most active cell multiplication is in this layer. In general, however, epithelial masses are sparingly provided with lymph channels, and cell growth proceeds from the deepest cells towards the surface.

Epithelial cells, whose surfaces are in contact with currents of air or of fluid, which requires to be passed on and not absorbed, are beset by *cilia* (see vol. i. p. 847). Recently it has been shown that the organization of these cells is much more complex than had been supposed (see Heidenhain, *Anat. Anzeiger*, 1899, No. 5), and that the cilia are connected with specialized portions of the reticulum of the cell substance, so that their motion is really a part of the motion of the whole reticulum. Such cilia are found in the nostrils, pulmonary air-passages, Eustachian and Fallopian tubes, and a few other places. (For further particulars concerning cilia, see Henneguy, *Archives d'Anat. microscop.* 1898; Studnicka, *Sitzb. d. kgl. böhmischen Gesellsch.* 1899; Gurwitsch, *Anat. Anzeiger*, 1900.)

Nerve-endings are minute and with difficulty traceable in ordinary epithelium; but in some cases there is a much more abundant nervous supply, which reaches its climax in the organs of the special senses. The essential character of each of these is the presence of one or more layers of *sensory epithelium*, whose component cells are elongated on their free surface into one or more exceedingly fine rod-like processes. These and the reticulum of the cell-body are organized in a more or less complex manner according to the nature of the impulse to which they are designed to respond by vibration, and each cell is in direct connexion with a nerve-ending. The forms of sensory epithelium are described in connexion with the specific sense organs (vol. i. p. 881 *et seqq.*). (For further researches, see Ramón y Cajal, "Le rétine des vertébrés," *La Cellule*, ix. 1893; Retzius, *Biologische Untersuch.* 1893, and Lenhossék, *Anat. Anzeiger*, 1893.) Embryologically, each sense-organ is a specialized area of dermal epithelium (except perhaps in the case of the tongue, whose surface is originally hypoblastic).

Gland-cells.

Epithelial cells which line pits or are otherwise placed in positions where they receive an abundant supply of nutrition (*gland-cells*) are usually highly metabolic, and have the power of separating from their substance by some process as yet unknown certain enzymes or other derivative material which they extrude, dissolved in some of the more fluid parts of the cell-content. These secreting cells undergo a physical change during their condition of activity, altering in appearance and reaction; but as yet no intelligible physical explanation has been given of this process, or of the correlation which exists between the specific enzyme produced by each gland and the physiological necessity of the part of the organism in which the gland lies. Sometimes single gland-cells occur in a continuous epithelium, as, for example, the mucus-secreting goblet-cells on the villi of the small intestines; but, generally, gland-cells are arranged at the bottom of tubular pits for the convenience of nutrition and of the accumulation of the secretion. The forms of the several kinds of glands depend on the degree of branching of these gland tubes. (On the structure of glandular epithelium, see Langley, *Journ. of Physiol.* 1889; and Nicolaïdes, *Centralblatt für Physiol.* 1889.)

Nervous tissue.

Nervous tissue is the recipient of all stimuli, the seat of all sensations, the starting-point of all motor impulses, the regulator of vascular and other activities, and the controller of the processes of nutrition and secretion. It is connected with every organ, and its terminations are distributed in almost every tissue of the body. It is not to be wondered at, therefore, that its structure is of amazing complexity, or that our knowledge of it is as yet imperfect and fragmentary. The morphological conception of the organization of nervous tissue has undergone fundamental modifications in recent years, as the structure of its component form-elements has become better understood. The methods of staining introduced by Golgi and Weigert have rendered it evident that these elements are distinct from each other, and that their communications are indirect. The unit of structure which is called a *neurone* (Fig. 4) consists of three parts:—(1) A cell-body or *perikaryon*, containing a nucleus with a complex *karyomiton*; around this nucleus are other chromophile elements called *Nissl bodies*, capable of being stained by methylene blue, while the rest of the perikaryon consists of a twofold achromatic substance, a fibrillar or spongioplasm-element, supposed to be conductive, and a fundamental or trophoplasm-element, supposed to be the seat of metabolic chemical changes. (2) A single filament or *axon*, starting from the perikaryon by a cone of origin containing no chromatic elements. After a course of variable length this becomes coated with a sheath of myelin, and passes, often far afield, to its ultimate destination, terminating by branching into a short tuft of filaments which may be included in a muscle fibre or other end organ, or else may be in close proximity to, but not in contact with, the second order of processes, about to be described, of another perikaryon. On its way to its terminal tuft an axon may give off collateral filaments, which also may end in one or another of these ways. (3) From the other end of the perikaryon, usually from a part containing chromophile elements, there arises a series of one or more short, repeatedly-branching filaments, called *dendrites*, which form an arborescent outgrowth from the nerve-cell, and are related to the terminal tufts of the axons of contiguous cells. At the ends of the dendrites are small enlargements called *gemmules*, and sometimes sharp-pointed processes called *thorns*. It has been supposed that the nerve currents in the dendrites are cellipetal and in the axons cellifugal. The motor nerves are all axons of cells, and it has been supposed that the sensory fibres are elongated dendrites.

The aggregations of neurones derived from the epiblast of the dorsal groove of the embryo make up the nervous centres. Other peripherally distributed neurones make up ganglia. In different parts of the nervous system the arrangement of the neurones varies in grades of complexity. In the simplest cases the dendrites carry the sensory impulse to the nerve-cell, wherein the wave of nerve force is in some unknown way reinforced, possibly by metabolic change in the trophoblast or the chromatic element, and is discharged as a motor impulse centrifugally along the axon to the muscle in which it ends. Sometimes the circuit consists of two neurones, one receiving and transmitting the sensory stimulus by its axon to the vicinity of the dendrites of the cell whose axon goes to the muscle. Sometimes a third or even a fourth association-system of neurones may be interposed between the tuft of the first axon and the dendrites of the last or motor cell. The method of relationship between the neurone networks is called *synapsis*; and there is reason to believe that the degree of approximation of the filaments in these is not always constant, but that sometimes the contiguity of some groups of processes may become close, while in other instances they may recede from each

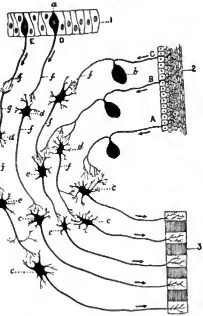


FIG. 4.—Diagram illustrative of the neurone theory. Each neurone consists of perikaryon (*b*, *c*, *d*, *e*), axon (*f g*), and dendrites. A, Simple arc of two neurones, one having its dendrites as sensory recipient fibres in the skin (2), and its axon ending in branches forming a synapsis with the dendrites of the motor cell (c), whose axon ends in the muscle fibre (3). B, Arc in which a ganglionic neurone (*d*) is interposed between the sensory and the motor neurones. C, Arc in which an additional or associative neurone (*e*) is interposed between the ganglionic and the motor neurones. D, Arc in which the perikaryon of the sensory cell is in the recipient epithelium of a special sense organ (1) such as the retina. A ganglionic neurone (*d*) is interposed between this and the motor neurone. E, a similar arc with an associated neurone between the ganglionic neurone and the motor.

other, and thereby the conveyance of whatever influence travels from neurone to neurone may be accentuated or hindered. The details of these groupings and of nerve-endings will be considered in connexion with the splanchnology of the nervous system. (For further particulars of the neurone theory, see Hoche, *Die Neuronenlehre*, Berlin, 1899.)

Nerves.

Each bundle of processes which leaves the central masses of nerve-tissue in its course towards its peripheral termination is called a nerve. The courses of these nerves can be followed by dissection, but the modes in which they end can only be ascertained by methods of staining, section-cutting, and microscopical examination. Within the central masses of nerve-tissue the courses of the fibres are intricate and obscure, and methods of staining and section give only imperfect differential criteria whereby individual bundles may be traced. The two methods which are most instructive are those which may be respectively called the experimental and the embryological:—(1) When an axon is detached from its cell it degenerates through all its length to its terminal tuft; so by dividing the axons coming from any group of cells their course, as distinguished from otherwise arising axons, becomes apparent in a series of successive sections stained to show such as are degenerated. (2) It is found by observation on developing nerves that some fibres acquire their myelin sheath sooner than others; so by making successive sections of an immature part, and staining the myelin sheath, any group of fibres already myelinated can be differentiated from those not as yet invested with this layer.

Muscular tissue.

Muscle is contractile tissue derived from the cells of the middle embryonic layer and consisting of elongated fibre-like cells, whose reticulum is regularly disposed, and whose enchylema or trophoplasm is charged with myosin and other proteids. These protoplasm-elements are so organized that when the cell contracts its two extremities are approximated. The three varieties of muscle—unstriped, cardiac, and striped—as well as some of the views which are currently held respecting their minute structure have been referred to in vols. i. p. 856 and xii. p. 8; but as yet the real nature of its organization has not been made out, and it is not improbable that many of the appearances described by observers are factitious, produced by the actions of reagents. The observations of Ramón y Cajol and van Gehuchten have led them to regard the fibre as consisting of a reticulum comparable with the cytomiton of a cell in whose interstices is an inter-reticular enchylema. Rollett, on the other hand, regards the reticulum as being composed of partitions of non-contractile sarcoplasm around a series of contractile sarcostyles. Merkel and Engelmann believe that the fibre consists of alternating masses of two materials which differ in their optical properties. One of these is anisotropous, and this may possibly during contraction absorb, or during relaxation discharge, a fluid yielded to it by the isotropous band, altering thereby its width and surface tension. In view of the conflict of opinion new methods of research are required before any positive pronouncement can be made as to the ultimate histological analysis of the muscle fibre. (For discussions of these views, see van Gehuchten, *Anat. Anz.* 1888-89; v. Kölliker, *Gewebelehre*, 1890; Rollett, *Wiener Sitzungsber.* 1889; Engelmann in *Hermann's Physiology*, i. 2; and M'Dougall, *Journ. of Anat.* Jan. 1898.)

Structure of the muscle.

Whatever may be their intrinsic structure, the mode of grouping of striped or voluntary fibres is easily ascertained. They are surrounded by a fine areolar tissue, called *endomysium*, in which the nutrient capillary vessels ramify and by means of which they are united into bundles. Each such fascicle of fibres is surrounded by an areolar sheath or *perimysium*. Groups of these bundles are united into larger masses, which are so arranged as to be capable of acting as motor units in the economy of the body. Each of these is invested with an areolar sheath, and is called a *muscle*. The ends of each muscular fibre are attached to the connective tissues with which they are in contact. In general, there is a filament of white fibrillar tissue firmly united to the end of each fibre, and the collective masses of these filaments at the extremities of a muscle are called its *tendons*. By these the muscle is tied to the parts of the skeleton, from and on which it acts. The lengths of the fleshy fascicles of muscular tissue are proportional to the mobility of the point of insertion, being just long enough to draw that part to the extreme of its possible excursion; so, if the distance between origin and insertion exceed this, the tendons at either or both ends are of sufficient length to occupy the remaining space. It must be remembered, however, that, embryonically, tendon and muscle arise independently, and that their connexion is secondary.

Muscles are apt to degenerate from want of use. In extreme cases the contractile tissue vanishes, leaving its connective framework as a fibrous mass. This takes place by natural selection, as muscle is an expensive structure to maintain owing to the amount of nutrition it requires. On this account, also, the fleshy bellies of muscles tend to become accumulated as near the base of supplies as possible; that is, as near the main vessel of the limb or the axis of the body.

The arrangement of the fascicles is not the same in all muscles. In some they run in direct lines, from origin to insertion, as in the rectus abdominis; in others, such as the pectorals, they converge from a wide origin to a narrow insertion so as to concentrate their useful work in moving one point. Muscles of the former group are called prismatic or bandlike; those of the latter, triangular or pyramidal. In a third group the fibres pass obliquely from origin to insertion, so that their action is decomposable into two components, one of approximation and one of translation, the relative sizes of which depend on the angle of the slant of the fibre with regard to the axis of the bone into which they are inserted. Owing to the exigencies of the formation of the skeleton most muscles belong to some species or other of this third class of rhomboidal muscles. A very common special case of this group is that of *penniform* muscles, in which a large number of short fibres are attached obliquely to an elongated tendon, as the barbs of a feather are to its axis. By this formation the number of short fibres in a slender muscle can be greatly increased without its becoming unduly thickened at any point. There is a certain small loss of useful work owing to the obliquity of the fibres, but this approximation-element is generally a negligible quantity, being only equal to the product of the force into the sine of the angle, which is usually very small.

Nervous and vascular supply.

One or more nerves or blood-vessels enter into each muscle. The point of entrance is at that spot at which the muscle moves least on the contiguous structures, and is usually on the aspect which is farthest from the surface, and, in the case of the vessels, nearest to the main artery of the limb. The nerve on entering breaks up into branches in various ways, the exact pattern of division depending on the arrangement of the fibres in the muscle. (See Disse in *Journ. of Anat.* Oct. 1897.) Ultimately, a nerve-twig passes into each muscular fibre and terminates in an end plate. The proportion between the number of nerve fibres entering a muscle and that of muscle fibres is in the external rectus oculi 1:8, in the soleus 1:350. In general, the nerve to each muscle comes from a single source, but in a few cases muscles are diploneural. Thus the brachialis anticus is supplied both by median and musculo-spiral nerves. The double supply generally indicates the fusion of two muscle germs, which have originated independently. When the area of origin of a muscle includes parts which are discontinuous or independently movable, the portion arising from each such part remains partially separate from the rest, and the muscle becomes two-headed. This condition may also occur from the interjection of a vessel or nerve, or from the synthesis of separate segmental elements in the one muscle. In like manner, a double insertion may arise from the separate mobility of the structures into which the muscle is inserted. Some muscles present two or more successive fleshy bellies, and are called in consequence digastric or polygastric. In such cases the several bellies have been separate morphological units, and have independent nerve-supplies.

Connective tissue.

Connective tissues are derived from the middle embryonic lamella and make up more than two-thirds of the body, forming its framework and the supporting skeleton of the more metabolic and physiologically active elements of each organ. Every epithelial layer is based on a lamella of this tissue; every muscular fibre is sheathed by a connective layer, and is attached to, or acts on, the connective tissues around its extremity. In this tissue there are three form-elements—(1) cells, which are usually flattish, often processed, rarely or never contractile, and consist of a distinct cell-wall and a comparatively small amount of protoplasm; (2) intercellular substance, copious in amount and traversed by numerous lymph canals; and (3) fibres, which may be of two kinds, either white, non-extensile, arranged in more or less wavy bundles of parallel fibres, or yellow, highly extensile and resilient, arranged in frequently dividing and uniting bundles.

Bone.

There are many varieties of connective tissue in the animal body (see i. 849 and xii. 6). The typical form is that called *areolar tissue* (Fig. 3). This consists of irregularly-interlaced wavy bundles of white and yellow fibres in a copious ground-substance, through which are scattered a number of flattish or branched cells. When immature the ground-substance is continuous and abundant; but in the adult it diminishes and becomes broken up by the formation of gaps or spaces, which give it a somewhat spongy texture, so that it can be inflated with air or infiltrated with fluid. This tissue is almost universally diffused in the body, varying in texture in each part according to local requirements. Under each layer of epithelium it forms a dense, almost structureless, *basement membrane*. In some organs its meshes are numerous and fine, containing entangled in them large masses of white lymph-corpuscles, which congregate and multiply in these spaces. This form is known as *adenoid tissue*. In some regions groups of connective tissue-cells are closely packed together, and their cell-contents become charged with oily or fatty material. Masses of this nature make up *adipose tissue*. In other cases the fibre elements, either white or yellow, preponderate. The white fibrillar is the toughest tissue in the body; a thread of it, measuring 1 square millimetre in section, bore without rupture a weight of 8940 grammes, while a cord of yellow tissue broke with a weight of 4040 grammes. *Cartilage* and *bone* are special varieties of connective tissue. In the former the tissue makes solid masses, in which the cells, either separate or in small clusters, are embedded in a hyaline matrix of ground-substance with or without fibrous elements. In some invertebrates and lower vertebrates a form of cartilage exists which contains mucin instead of chondrogen, recognized by its staining yellow with thionin. Bone is characterized by the calcification of its ground-substance, which becomes infiltrated with lime salts, while for the most part the fibres and the branched connective corpuscles remain uncalcified (see vol. i. p. 852). The physical properties of bone fit it in an eminent degree to form the skeleton of the animal body. When its specific gravity, its breaking limit with tensile strain, its crushing limit when subjected to pressure, and its modulus of elasticity are compared with those of other materials, this superiority becomes apparent. (See Lesshaft, *Theoret. Anat.* Leipzig, 1892.)

In the following table the numbers in the second and third columns are the weights in pounds avoirdupois required to break or crush a square rod of the material 1 mm. in diameter. The modulus of elasticity is the weight in pounds which, if these substances were perfectly elastic, would be required to lengthen the square rod to twice its original length. To compare these so as to determine the skeleton-building suitability of each material, the number in each column should be divided by the specific gravity of the material:—

Substance.	Sp. Gr.	Tensile.	Crushing.	Elasticity.
Steel	7·816	225	319	46,300
Wrought-iron .	7·788	90	48	41,887
Cast-iron . .	7·207	23	160	...
Bone	1·870	26	33	5,291
Oak	0·845	14	10·5	2,425

The important factor that the skeleton must present a surface of sufficient extent to give attachment to the muscles of the body makes it necessary that the material of which it is made must be of comparative lightness. Bone is the most vascular form of connective tissue and the most active in nutritive changes. In general, connective tissues are low in vitality; their elements contain but little protoplasm, and in consequence they easily suffer necrosis.

Chemistry of connective tissue.

All forms of connective tissue begin as an indifferent embryonic mesenchyma, whose subsequent differentiations are reactions due to the influence of environing conditions, which are usually definite and recognizable. Hence the history of the connective tissues of the body forms an important chapter in dynamical ontogeny. The chemical relations of the different forms of connective tissue are generally characteristic. The white fibrils and ground-substance of areolar and white fibrillar tissue yield gelatine on boiling, cartilage yields chondrin, and yellow tissue consists of a substance which resists acetic acid and boiling water, and is named elastin. The animal part of bone in most respects agrees with that of white fibrillar tissue. The process of ossification has been described in vol. i. p. 855, where it is noted that it may take place either in cartilage or in membrane. This is an important consideration in the determination of bony homologies, for a bone which was originally cartilaginous is morphologically of a different order from one which started as a membrane. The reason is not far to seek. It is not that the processes differ intrinsically, but the early stages of the ancestral history recapitulated in its embryogeny must be diverse as the embryonic tissue has become so diversely differentiated. The history of the progress of ossification has been greatly elucidated by the use of the Röntgen rays, whereby the bony nuclei can be detected at their first formation, and their growth and union can be traced in the living adolescent.

Formation of cavities.

In some cases in which large clefts occur in masses of areolar tissue the tissue forming the boundaries of such clefts consists mainly of flattish connective cells, which in some cases are close enough to simulate pavement epithelium. Such a layer is called *endothelium* to distinguish it from the true epithelium. This term, though etymologically objectionable, is in the main convenient, and is in general use. These clefts are of four kinds—joint cavities, bursæ, sheaths of tendons, and serous cavities. In *joint cavities* the surfaces of the bone are covered with cartilage, and have no endothelial coating, but the ligamentous side-wall of the joint is lined with a specially smooth connective layer, named synovial membrane (Fig. 5). On the surface there are often patches of endothelium, although never a continuous layer of such cells. Groups of endothelial cells, however, are often clustered on fringes at the margin of the bones in these cavities, and these secrete a mucilaginous exudation called *synovia* (vol. i. p. 833). *Bursæ* are clefts between planes of firm areolar or fibrillar tissues which glide on each other. These are also lined by synovial membrane, but never present a continuous endothelium; indeed, in many bursæ these are only represented on a few of the synovia-secreting processes. The same is true of the sheaths of tendons. *Serous membranes* form a separate category, for, while in

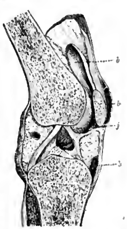


FIG. 5.—Vertical section through knee-joint, with the bones somewhat drawn apart, showing the synovial cavity of the joint (*j*) and the bursæ (*b*) in its vicinity.

the higher vertebræ the cœlom or body cavity which they line is formed by a splitting of the mesoblast, the comparative embryology of this cavity shows that originally in the most archaic vertebrates it was formed by the outgrowth of diverticula from the primitive gastræal cavity. It is consequently possible to sustain the thesis that the apparent delamination in the higher forms is due to the superposition of a series of processes of development which occur successively in the lower, but simultaneously in the higher vertebrate. Hence it is conceivable that the lining material of the cœlom may be not an endothelium, but a true epithelium. The same may possibly be the case in the great blood-vessels. At the same time it must be remembered that it is not possible to draw hard-and-fast lines between the derivatives of the several germ layers, whose distinction the one from the other is not so definite as was once imagined. Serous membrane is always lined by a continuous layer of pavement cells, resembling pavement epithelium in almost every respect, and the same is the case with the blood and lymph vessels.

SPLANCHNOLOGY.

Organs.

A mass made up of various tissues united so as collectively to discharge some special function is called an *organ*. Proximately the human body consists of an assemblage of organs arranged in a definite manner, and the study of the structure of these organs and of their relative positions constitutes the subject-matter of Descriptive Anatomy. Organs may be classified physiologically according to their respective offices into seven groups—(1) those of protection and support (skeletal); (2) of motion (muscles); (3) of sensation, the seats of the reactions dependent on and related to sensation and psychic process (nervous); (4) those whereby food is taken in and assimilated (digestive); (5) those whereby the nutritive material is distributed to the tissues (circulating); (6) those whereby waste products are got rid of (eliminative); and (7) those by which reproduction takes place. Morphologically, organs may be divided into two groups, according to their relation to the originally segmented constitution of the body. The human body, like that of all vertebrate animals, is made up of a chain of segments, each of which is more or less built on a common plan. The organs of the 1st, 2nd, 3rd, 5th, and some of those of the 6th group are segmental in original plan, although in the course of development this characteristic has become obscured. Those of the 4th and 7th, and some of those of the 6th group show no sign of ever having been segmented at any stage in their ontogeny.

I. *Organs of Protection and Support.*—All the active tissues of the body are supported on a framework of connective tissues, or else are contained in spaces bounded by lamellæ of these tissues, which thus constitute the skeleton of the organism. (The word skeleton is popularly limited to the bony framework, but, morphologically, all the connective tissues are equally parts of the vertebrate skeleton.) A layer of extremely condensed areolar tissue invests the whole body, forming the true skin, *cutis* or *dermis*. This is truly skeletal, and in some lower vertebrates is the only tissue in which ossification occurs. Beneath this is a laxer layer, also of areolar tissue, differing from the last chiefly in its lesser density, in its containing more or less fat in its meshes, and in its being traversed by vessels and nerves, which do not end in it as they do in the denser cutis which invests it. This layer is called *superficial fascia*, and, like the skin, it is continuous over the whole body.

Beneath the superficial fascia there is in most parts of the body a firm, thin layer of white fibrillar tissue, which covers the muscles and is attached to those prominences of bone which project beneath the skin. To this the name *deep fascia* is given. Partitions of this material dip in between groups of muscles, and are called intermuscular septa. Other lamellæ form sheaths for vessels, nerves, and viscera. The deeper connective tissues forming the main axis of the body, to which the name skeleton is commonly limited, are composed of bone, cartilage, and fibrous tissues, and are disposed segmentally. They consist (1) of the vertebral column, and (2) of the skeletal walls of the two great tubes of which the vertebrate body is made up, the dorsal or neural, and the ventral or visceral. The walls of these tubes are united to the investing layers of deep fascia by four longitudinal partitions—one mediodorsal, one medioventral, and two lateral—subdividing the body wall into four areas, two dorsolateral and two ventrolateral.

Segmentation.

At their first appearance in the embryo the continuity and segmental arrangement of these connective masses and partitions is obvious; but in their later conditions, when parts of this skeletal apparatus are transformed into cartilage and bone, though to some extent appearances of segmentation still persist, yet these are often of derivative origin, and do not coincide with the primary segmental divisions. For in the course of development the primary intersegmental clefts are in part seen to fade and a secondary series to appear; these, instead of coinciding, are for the most part alternate with them. This secondary segmentation occurs especially in the tissue around the notochord or unsegmented axial rod (vol. i. p. 830). This notochord is no part of the skeleton; it was originally a canal, but in the absence of any animal which preserves this structure as such it is difficult to understand what was its original function (Fig. 6).

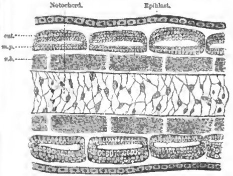


Fig. 6.—Diagram constructed from several sections of the vertebral region of the embryo shark. Showing the formation of vertebral bodies (*v.b.*) around the notochord, by the rearrangement of the scleroblasts or inner cells of the original protovertebra, the lines of segmentation of these rearranged segments being alternate with those of the original protovertebra, as shown between the muscle plates (*m.p.*) and cutis plates (*cut.*), from which the muscular system and dermis are respectively developed. The epiblast gives rise to the cuticle. Between the muscle layer and the cutis layer is the segmented portion of the cœlom.

It probably was an archaic form of alimentary canal, around which were disposed the segmented skeletal and other tissues. The connective tissues which surround it become the successive vertebral bodies, and their uniting fibrous discs, from the former of which the neural arches project dorsally, and the costal or rib arches ventrally.

Vertebræ.

To the description of the vertebral column in vol. i. p. 821 it is only necessary to add that the morphological relationships of the parts in successive vertebræ are not so simple as they appear at first sight. Each vertebral body originates as two separate elements—one a perichordal ring, arising in two symmetrical parts, one on each side of the notochord, and a second or hypochordal arch connected with the bases of the neural and visceral arches, lying on the ventral side of the perichordal elements and on a level with the interval between contiguous perichordal rings. This hypochordal element merges with the perichordal in all vertebræ, except the first cervical. In this it remains separate and ossifies as the anterior arch of the atlas, while the corresponding perichordal ring becomes the odontoid process of the axis. The successive vertebræ throughout the whole column consist of comparable parts modified in each region to suit the mechanical condition of the region. The most variable portion of each vertebra is the transverse process, an outgrowth from the base of the neural arch, which is usually multiple. It is not so much a morphological unit as a variably-arranged area for the attachment of oblique intervertebral muscles. In the cervical region it is tripartite—(1) its dorsal portion, existing as a mere roughness on the dorsal side of the articular mass for muscular attachment; (2) its ventral portion is fused with the rudimental costal process; and (3) its intermediate part, which projects into the lateral septum, is joined at its lateral end to the ventral portion, bounding with it a hole for the ascent of the vertebral artery. In the thoracic region the parts corresponding to the 1st and 3rd of these elements unite into a single transverse process, while the ventral part is flattened into a costal articular facet. The ribs, which are detached extensions of these costal processes, do not really articulate with the bodies of the vertebræ, but in fœtal vertebræ it can be seen that the entire rib articulation is on the neural side of the suture between the neural arch and the centrum or body. The three elements are distinct in the 12th thoracic vertebræ. In the lumbar region the ventral part is, as in the cervical, inseparable from the costal element, making with it the process that is usually erroneously described as the transverse process. The two others exist as rough spurs, called respectively the mammillary and accessory processes. The human vertebral column in its earliest stage consists of thirty-eight vertebræ. Of these the two hindmost vanish before chondrification takes place, and the four which precede these unite into an irregular mass, the last of the four pieces of the coccyx.

Nature of limbs.

The appendicular skeleton is described in vol. i. p. 838. The morphological nature of the vertebrate limb is still a disputed point; but the balance of evidence is in favour of Balfour's theory, that each limb is the surviving part, anterior or posterior, of a lateral ridge, which originally extended along the side of the vertebrate body, and each consists of material derived from at least seven successive segments. Gegenbaur, however, has made out a plausible case for the hypothesis that the limbs are modifications of the processes of a gill arch, and Graham Kerr has proposed to regard the limbs as derived from external gills (*Proc. Camb. Philosoph. Soc.* 1889).

The parts of the skeleton of the human *forelimb* present certain characters which distinguish them from those of other mammals. The scapula is longitudinally elongated and transversely short, so that its maximum breadth only equals about 0·70 of the length. This "scapular index" is usually greater in the black races, and is higher in the fœtus than in the adult. The humerus in man exceeds the radius in length as 1 : 0·7, the numerical relation being known as the humero-radial index. This also is larger in the lower races. The human thumb is perfectly opposable to the other digits as is that of no other vertebrate. There are normally eight bones in the human carpus, but embryonically a ninth or *os centrale* is present in vestige, fusing at an early period with the scaphoid or semilunar, and only remaining distinct as a rare anomaly, although its rudiment is by no means uncommon. The pisiform bone of the human carpus is in all probability the reduced vestige of an obsolete sixth digit, and is not, as has been supposed, a sesamoid bone. The *hip-bone* presents markedly different characters in the two sexes, which can be recognized as early as the fifth month of fœtal life. On account of these differences the shape of the cavity of the pelvis bounded by these bones is also distinctive, even in the fœtus. In the males of the white races of mankind the sagittal (antero-posterior) length of the pelvis is, in average cases, to the coronal (transverse) length as 80 : 100; but in those of the black races it is related as 95 : 100. A slight difference has been observed in the level of the articulation of the hip-bone with the sacral vertebræ at different periods of life, the tendency being for the former to rise to a higher level as development advances. In the earliest period of fœtal life at which these elements can be distinguished the first sacral vertebra is not at all involved in the articulation; but as age advances it gradually becomes included in the joint, and occasionally the twenty-fourth vertebra becomes also on one or both sides directly articulated to the hip-bone, and correspondingly incorporated in the sacrum.

The *femur* constitutes usually about 0·275 of the individual stature; but this proportion is not constant, as this bone forms a larger element in the stature of a tall than of a short man. The human femur presents also a concave popliteal surface, thus differing from that of Pithecanthropus, whose popliteal surface is convex. In the bones of some races the dorsal ridge of the thigh-bone (linea aspera) projects as a prominent crest causing the bone to appear "pilastered," a condition the amount of which is indicated by the increased relative length of the sagittal to the coronal diameter of the bone. Pilastering, though characteristic of lower and primitive races of men, is never found in the anthropoids. The upper third of the femur in some races is sagittally flattened, a condition which is called *platymeria*. Its degree is indicated by the excess of the coronal over the sagittal diameter in this region.

The *tibia* in most civilized races is triangular in the section of its shaft, but in many savage and prehistoric races it is two-edged. The condition is named *platycnemia*, and is indicated by the proportional excess of the sagittal over the coronal diameter. The fœtal tibia has its head slightly bent backwards with regard to the shaft, a condition which usually disappears in the adult, but which is shown by the prehistoric tibiæ found in the cave of Spy. In races that squat on their heels the front margin of the lower end of the tibia is marked by a small articular facet for the neck of the astragalus.

The *fibula* is a variable bone. In prehistoric and savage races its several surfaces are often deeply channelled. In fœtal life its lower ankle-swelling is smaller than the inner ankle of the tibia, but this relation becomes reversed in the adult. The human foot is plantigrade, the metatarsal bone of the great toe being nearly parallel to those of the other toes, unlike those of the anthropoids. Very often in the adult the second and third phalanges of the little toe are ankylosed together. This is no new thing nor is it necessarily a product of civilization. The writer has found it thirty times in the feet of ancient Egyptians, and once in those of an aboriginal Australian. The intermembral relation of humerus and femur is important in physical anthropology, as are also the relative lengths of the femur and tibia.

Skull.

The varieties of cranial shape which are distinctive of the different races of mankind are due especially to the interaction of four factors—(1) brain size and shape; (2) dental size and degree of development of the muscle of mastication; (3) the sizes of the several sense organs; and (4) the sizes and extents of certain muscular areas. The methods commonly in use for estimating these varieties are numerical indexes, which are the centesimal relations of certain measurements. These are convenient, although often fallacious. Thus, for example, brachycephaly or broad-headedness, indicated by the breadth being more than ·80 of the length, may be due to the survival of an infantile character, as in Negritos, or to a secondary increase in the width of the hinder part of the frontal cerebral lobes, as in the Teutonic Europeans. Similarly dolichocephaly (with the breadth ·75, or under, of the length) may be due to increased length of frontal and parietal areas of the brain (indicated by increased preauricular length), or to diminution of the parietal width and increased occipital length. Most other composite cranial measurements hitherto made are equally faulty.

The human skull is frequently the subject of deformation, due to premature union of some of its sutures constraining its growth. Thus, if the two parietals unite in fœtal life or infancy, the skull becomes *scaphocephalic*, as represented in vol. i. p. 832, Fig. 14. When the union is of the coronal suture, the skull becomes short and high, or *thyrsocephalic*; if the halves of the frontal unite before birth, it is wedge-shaped or *trigonocephalic*. The vertebral theory of the skull has been discussed (vol. i. p. 831), and is now definitely abandoned by all morphologists. On the other hand the original segmentation of the cephalic region has been abundantly demonstrated; the only difference of opinion among observers has been in the estimation of the number of segments in the cephalic region of the primitive vertebrate. These segments, however, had lost their distinctness even before the cartilaginous cranium had become developed, so that there is no real segmental value in the elements of this, still less in those of the bony skull. The only place in which segmental elements can be distinguished is in the occipital region, which is in structure transitional between the head and vertebral column. (For an excellent account of the human skull, in which the many new morphological details due to recent investigation are set forth, see Graf Spee in *Bardeleben's Handbuch der Anat.* i. 2.)

Joints.

To the account of the joints and ligaments of the human body in vol. i. p. 834, it need only be added that ligaments are not all of the same morphological value. The capsules of most of the joints are derived from the connective tissue which forms the circumference of the primary articular cleft in the embryo (vol. i. p. 833, Fig. 16); but the accessory or lateral ligaments are often of secondary formation, derived from displaced tendinous appendages to muscles or intermuscular septa, or they may even be the connective sheaths of muscles which have lost their fleshy substance. The function of ligaments is chiefly to supplement the muscles in protecting joints. They are generally weak where the muscles are strong, and it is noteworthy that joints are more frequently dislocated at the places where the muscles are feeblest, irrespective of the strength of the ligaments. The menisci, whose formation has been referred to and illustrated in vol. i. (p. 833, Fig. 17), are not always the simple survivals of an interjected layer of the capsule; in some cases, as in the triangular cartilage between the ulna and carpus, the cartilage may contain a vestigial skeletal element, and the same may be true of the sterno-clavicular cartilage.

II. *Muscular System* (see vol. i. p. 834 *sq.*).—The voluntary muscles of the body may be grouped in three series—those derived from the muscle plate of the protovertebræ; those originating in the somatopleure; and those originating in the nephromere or region of the segmental organs. The muscles arising in the splanchnopleure are the unstriped muscles of the viscera.

From the muscle plates arise the axial muscles of the dorsal series, including the deeper layers of the muscles of the back. The orbital muscles also originate from cephalic muscle plates. In the trunk this series is trilaminar, including (*a*) the longitudinal muscles of the spinal column, (*b*) the intermediate oblique series of semispinales and multifidi, and (*c*) the deep, short interspinal and rotator muscles, which stretch from vertebra to vertebra. All these are innervated by the dorsal branches of spinal nerves, and they are limited dorsally by the strong dorsal fascia, and ventrally by the lateral intermuscular septum.

The somatopleural muscles originate in the body wall beyond the edge of the muscle plate. As it is from this structure that the limbs are outgrowths, these muscles may be divided into two series—those of the trunk (ventro-axial), and those of the limb (appendicular). They are all innervated from the ventral branches of the spinal nerves and lie on the ventral side of the lateral septum. These muscles are divided into laminæ. A superficial external oblique layer is continued in the thoracic region over the ribs. A second or internal oblique layer becomes intercostal in the thorax. A third or transverse layer lies on the visceral side of the ribs. On either side of the medio-ventral line these three layers are represented by a continuous mass, the rectus abdominis, from which, sometimes, the pyramidalis is a superficial and partial delamination. Occasionally there is a superficial lamella attached to the skin—the panniculus, or skin muscle—which is only a delamination of the superficial layer, as shown by its development and innervation. The limb muscles are continuations of the supracostal stratum, modified by their connexions with the bony parts of the limb. They are throughout divisible into a dorsal and a ventral series, each of which is innervated by branches derived respectively from posterior and anterior divisions of the ventral trunks of the spinal nerves of the segments represented in the limbs. Those who hold the Gegenbaur or Graham Kerr hypothesis regard the multiple innervation of the limb as evidence of the secondary annexation of other nerves, in consequence of a gradual slipping backwards of the limb. These dorsal and ventral muscles of the limb are grouped into those attached to the limb girdle and those which extend to the first, second, or to the terminal elements of the limb ray. There is a certain general resemblance between the muscles of the two limbs as they arise from similar muscles-sheets; but as in all land-animals the fore and hind limbs are of necessity different in their mechanical relations, the *rôle* of the fore and hind limbs being essentially different in quadrupedal progression, these sheets from the first have undergone cleavage in different ways. Therefore, it is not possible precisely to homologate the different muscles of one limb with their equivalents in the other. The innervation of these sheets of muscle, however, shows that around the shoulder or hip there are four groups, which may generally be called abductor, adductor, flexor, and extensor; in those around the elbow as well as in those of the hand or foot there are three series, although two of these are confluent in the leg, where also the radial marginal group of muscles is absent. An important difference is to be noted between the muscles of the hand and foot in the position of the axis of movement of the digits. In the hand the short muscles are arranged so as to adduct to, or to abduct from, an axis passing down in the line of the middle finger, whereas in the foot the axis from and to which the muscles draw the toe passes down in the line of the second toe.

The muscles which are derived from the nephromeric region, sometimes called hypaxial or hyposkeletal muscles, are a few, small aberrant somatopleural slips which lie on the ventral face of the vertebral bodies and pedicles, such as the longus colli and others on the same horizon. They are innervated by branches from the ventral divisions of the segmental nerves.

The muscles of the human body exhibit very many varieties, an exhaustive study of which is given in Le Double's *Variations du système musculaire de l'homme*, 1897.

III. *The Nervous System.*—Considerable advances in knowledge and some changes in interpretation have been made since the writing of the remarks in vol. i. pp. 858-884. The vertebrate body in its early embryonic stages is made up of a succession of segments, in each of which there is a segmental nerve distributed to the parts of the segment. In process of development irregularities in the growth of the component elements obliterate or obscure the definition of the primitive division; but there is reason to suppose that the nerve constituents are more constant in arrangement, and furnish more accurate indications of the original segmentations than do the other tissues or organs. In the head, where the traces of original segmentation are practically obliterated, owing to the rapidity with which change succeeds change in early embryogeny, almost our only guide to unravel the morphological history is that furnished by the cranial nerves. The course of a typical segmental nerve is described in vol. i. p. 867. Such a nerve traced centripetally resolves itself into two roots, a dorsal and a ventral, close to its place of connexion with the spinal cord. The fibres making up the ventral root enter the spinal cord along its antero-lateral groove, are continued into the grey matter of the anterior horn, and prove to be the axons of the large branching cells of that horn. These neurones form the efferent or motor system whose terminal tufts are enclosed in the fibres of the voluntary muscles and other structures throughout the body. Some of the efferent axons of a spinal nerve end in tufts beside the dendrites of nerve-cells clustered in small visceral ganglia, which are arranged in a chain on the ventral surfaces of the vertebral bodies. To these the name *sympathetic ganglia* is given. The axons of these cells are distributed to viscera and vessels. The fibres making up the dorsal root are in essence processes of cells which form a series of ganglia close to the postero-lateral groove of the cord. Each cell of these ganglia gives off a short process, which divides into two branches that diverge from each other nearly at right angles, like the component halves of the horizontal stroke of the letter T. One of these is the fibre we have traced from the periphery as the sensory element of the spinal nerve; the other passes into the spinal cord, there to break up and to be connected synaptically with the neurones of other systems. The primordial segmentation of the vertebrate nervous centres has become overlaid and masked by the development of groups of neurones, which combine, co-ordinate, and otherwise influence the relations of the segmental nerve-cells. This is true of the spinal cord, but much more so of the brain.

Spinal cord.

As an account of the spinal cord has been given in vol. i. p. 865, it is only necessary here to trace the courses of the component systems of neurones in terms of the parts of the cord there described:—(1) Around the dendrites of the large cells of the anterior horn are the end-tufts of axons, which can be traced up to the medulla oblongata. These collectively form a thick white band, the *crossed pyramidal tract*, that lies on the lateral side of the dorsal horn. When it reaches the apex of the pyramid in the medulla oblongata the component fibres cross to the opposite side, decussating with those of the corresponding bundle of that side and ascending in the pyramid of the opposite side (vol. i. p. 870); then passing forward through the pons, crus cerebri, and through the middle of the corpus striatum, they end in perikaryons in the cerebral cortex. These cortical cells are closely linked together by numerous commissural and association neurones, to be described hereafter. By these fibres the cortex cerebri is brought into relation with the voluntary muscles, there being but two interruptions in the circuit. (2) Other axons, ending about the same group of anterior horn cells, pass across at once to the opposite side of the spinal cord, and then ascend in the mesial part of the white tract bordering the ventral fissure. They run up in the pyramid of their own side, and otherwise follow a course comparable with those of the last set. These make the *direct pyramidal tract*. (3) A wide curved band of white spinal cord substance stretches from the outside of the direct pyramidal tract outside, and in front of the ventral horn, as far as the edge of the crossed pyramidal tract. This consists of the axons of shorter neurones, which begin in nerve-cells in the grey matter of the cord at different levels. Some of these axons cross in the anterior commissure to the opposite side, while others pass down in this tract to end by synapsis with the dendrites of the cells of the ventral horn; thus, although this *ventro-lateral association tract* is apparently a continuous mass, it is made up of shorter and more varied axons than the foregoing. These three tracts agree in being descending tracts coming from nerve-cells on a higher level and in being connected with the ventral horn-cells by synapses, and thereby with the motor nerve roots arising from them. (4) Two groups of axons, mostly ascending, are closely related to these, and spring from the cells of the lateral cell column of Clarke (vol. i. p. 866), whose dendrites are contiguous with those of cells in the ventral part of the column. These axons form a thin layer on the lateral surface of the cord between the dorsal and ventral nerve roots, and they extend on the same side into the restiform body of the medulla oblongata above, by which they pass into the cerebellum. By this *cerebellar tract* the neurones of the cerebellum are associated with the spinal nerve system; and it has been inferred from experiment that these are connected, in some way as yet unknown, with the co-ordination of muscular actions. (5) From the cells of the ganglia above described, which form the segmental origins of the sensory fibres constituting the dorsal roots of the spinal nerves, we have already seen that T-shaped processes arise. The inner branch of each of these passes centripetally, and forms the link between the ganglion of the root and the spinal cord. The continuations of these form almost all the white matter that lies internal to the dorsal roots. Most of these fibres run upwards, but some descend to form synapses with dorsal horn-cells on a lower level. These send, as they pass along, collateral branches into the grey matter of the dorsal horn to end around the nerve-cells there. Neurones of this grey matter in turn send axons, which terminate above in tufts about the cells of the posterior columns of the medulla oblongata, and these again send axons in the fillet of the crus cerebri, to end, after interruptions in the thalamus, in tufts about some of the smaller, deeper cells of the cerebral cortex. Thus the effect of an efferent impulse, while for the most part propagated upwards, may be to some extent continued downwards, sometimes causing reflex action by affecting the region below it. By means of these bundles of fibres in the cord, the segmental nerves are linked together and so controlled as to act as component parts of a functional whole (Fig. 7).

The spinal cord is essentially bilateral. In the embryo it is formed of the lateral thickenings of the sides of the neural canal, and no neuroblasts (embryonic nerve-cells) arise either in the ventral or dorsal median portion of the wall of the canal. Whatever fibres at a later stage cross from side to side are invasions from lateral structures.

Brain.

The *medulla oblongata* or *bulb* is developed from the wall of that part of the neural canal which formed the hinder cranial vesicle, and lies immediately within the foramen magnum of the skull. In it the dilated neural canal forms the fourth ventricle, which dorsally is for the most part closed by a membrane, the superior medullary velum, as well as by the cerebellum. Through the medulla pass the ascending and descending axons of the various cerebro-spinal association systems. In it are also the segmental nuclei of the nerves of the series of nine hinder cranial segments, which have become secondarily grouped into the V.-XII. nerves of Human Anatomy. The *cerebellum* (vol. i. p. 871) lying on the dorsal side of the ventricle has originated by two lateral ingrowths derived from the

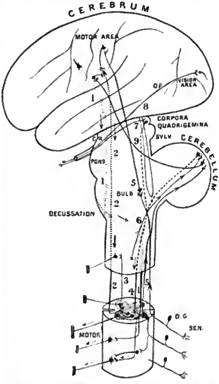


Fig. 7.—Diagram of the connexions of the motor and sensory nerves with the nerve centres. 1, Descending axons from the perikaryons of the motor centres in the cerebrum, decussating in the bulb, and united synaptically to the motor neurones in the cord; 2, axons which descend without decussating until they reach the level of the motor neurones, then crossing on the anterior white commissure of the cord; 3, associative neurones; 4, associative neurones connected with the cerebellum; 5, ascending axons from sensory cells, interrupted at the bulb; 6, ascending axons to cerebellum, ending by synapsis with associative neurones which connect cerebellum with cerebrum (9); 7, optic fibres from neurones in retina to corpora quadrigemina; 8, optic fibres to occipital region of cerebrum. OP, optic thalamus; CR, crus cerebri; DG, ganglion of dorsal root; SEN, sensory nerve.

tissues on either side, which ultimately fuse in the medio-dorsal line. With the neurones of this body the cerebellar tracts of the cord and several other series of association fibres passing to the mid-brain and thalamus are connected. The *mid-brain*, lying in front of the bulb, is the thickened wall of the second cranial vesicle (Fig. 7, SYLV.), which in man has contracted into a canal, the *aqueduct of Sylvius*. Its thickened floor is the *pons Varolii*, mostly made up of—(1) commissural cerebellar fibres crossing from side to side, traversed longitudinally by (2) bundles of the descending fibres of the pyramids passing between the cerebrum and the spinal cord. These longitudinal fibres pass forwards on each side from the hemisphere to the pons, forming a large part of the *crura cerebri*. (3) Between the bundles of fibres are many nerve-cells, with which some of these fibres are directly and synaptically connected. In the ventral floor of the canal in this region are the segmental nuclei of the third, fourth and part of the fifth nerve. The relations of the nerve roots to the cranial vesicles show that the latter are not primitive morphological features, but only secondary mouldings of the brain mass superinduced after the fusion of the original segments of the cephalic region. The *quadrigeminal bodies*, which in the human brain form the dorsal wall of the second cranial vesicle, are condensations into one irregular mass of several organically distinct series of neurones and their processes connected directly or indirectly —(1) with ascending axons from the dorsal roots of the spinal nerves, (2) with the wall of the anterior cranial vesicle, and (3) with the optic nerves. The original cavity of the fore-brain or anterior cranial vesicle becomes in the adult the *third ventricle*. Its side walls are thickened and form grey masses, the *optic thalami*. Its roof is membranous and contains no neurones, forming the velum interpositum. Median pouches of this cavity project—(1) upwards and backwards, and (2) downwards and forwards. The former has at its end the *pineal gland* or *epiphysis*, the vestige of a median eye, which is functional in Sphenodon and a few other reptiles; the latter, which is named the *infundibulum*, projects towards the sella turcica or fossa above the body of the sphenoid, and there thickens to form the posterior lobe of the *hypophysis* or *pituitary body*. This thalamic region is apparently related to the segment of the head which originally bore the eyes. The front of the fore-brain is a membranous area, the *lamina terminalis*.

Cerebrum.

The part of the brain which lies above and in front of the thalamic region is the *cerebrum* (vol. i. p. 872), whose enormous growth in the higher mammals has caused it to overlap and alter the relations of the neighbouring parts of the brain. Its structure presents many obscure and difficult points, especially in the higher mammalia. The cerebrum consists of two hemispheres, originally separate from each other. These are at first hollow outgrowths from the upper, anterior, and lateral angle of the fore-brain, containing evaginations of the third ventricle, which are called the *lateral ventricles*. These communicate with the parent ventricle by an aperture, the *foramen of Monro*, in front of which is the lamina terminalis. The composition of the wall of the cerebral hemisphere can only be understood by a careful comparative study of its ontology, traced from the lowest vertebrates to the highest mammals (Fig. 8). In the former this wall of the hemisphere on the medial aspect, in front of the lamina terminalis and above it, consists of—(1) a grey area, the *corpus paraterminalis*. Above this a faint line of demarcation (*sulcus limitans*) maps out (2) a second area, the hippocampus, which in some lowly-organized mammals forms the entire of the remaining part of the medial wall of the hemisphere. On the outer wall above there is (3) a definite area, the *pallium*, very small in lower vertebrates, enormous in the higher mammals. This is limited below and laterally by a *rhinal fissure*, which marks off (4) the *rhinencephalon*, or smell area, that makes up the rest of this wall. Above, the pallium extends to the margin of the hemisphere, where it is conterminous with the hippocampus. The floor of the hemisphere consists of (5) a grey mass, the *corpus striatum*, in front of which projects (6) a lobule, the *olfactory* bulb and pedicle, the latter of which often extends backwards, spreading around the corpus striatum to touch the paraterminal body and hippocampus on the inner side, and to form a *pyriform lobe* on the outer side, separated by the rhinal fissure from the pallium. All these parts in front of the rhinal fissure are included in the name rhinencephalon. Between the two hemispheres, as they grow, commissural neurones arise and send their axons across in the substance of the lamina terminalis, linking together the hemispheres. These become grouped in two bundles—one a dorsal commissure, the *fornix* or *psalterium*, which joins together the two hippocampal areas, and which in higher forms consists of longitudinal as well as transverse fibres. The other is ventral, and its fibres cross the basal region and rhinencephalon, consisting among others of the commissural fibres of the pallial area. In some animals a third commissure, the *commissura aberrans*, crosses the roof of the third ventricle behind the foramen of Monro (not to be confounded with the *commissura mollis* of an adult human brain). In such animals the roof of the third ventricle consists of the velum interpositum, a delicate epithelial layer attached on each side to the ventral lip of the paraterminal bodies. The lateral margins of this project into the foramen of Monro and constitute choroid plexuses.

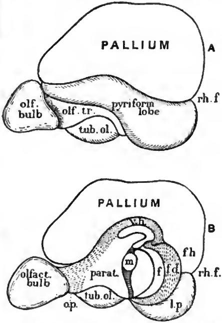


FIG. 8.—Scheme of the mammalian cerebral hemisphere. A, Lateral aspect. *rh. f.*, rhinal fissure; *olf. tr.*, olfactory tract; *olf. bulb*, olfactory bulb; *tub. ol.*, olfactory tubercle. B, Medial aspect. *v.h.*, vestigia hippocampi; *f.h.*, hippocampal fissure; *f.d.*, fascia dentata; *f.*, fimbria; *l.p.*, pyriform lobe; *parat.*, paraterminal body; *m.*, foramen of Monro; *o.p.*, olfactory peduncle.

These are, therefore, not parts of the wall of the hemisphere but of the fore-brain, and behind them is the aberrant commissure, which separates the choroid plexus from the membranous roof behind it (*paraphysis*), and lies at the caudal end of the paraterminal body. Behind the paraphysis is the commissure of the habenula in front of the pineal eye.

Characteristics of human brain.

The predominant characteristic of the brains of man and of the higher mammals is the enormous overgrowth of the pallium, which consists of those neurones that govern the lower mechanisms and whose functions are to initiate actions. Coincidentally with this growth, remarkable changes take place in the other areas of the cerebral surface. The hippocampus becomes indented by the development of a longitudinal sulcus on its median aspect, and is differentiated in structure from the surrounding parts by the formation within it of a compact layer of pyramidal cells. The bottom of this sulcus projects into the lateral ventricle, and there makes a swelling to which the name hippocampus is often limited, while the part containing the column of cells at the margin of the hippocampal area which still remains on the median surface of the hemisphere close to the paraterminal body is called *fascia dentata*. These pyramidal cells are probably receptive cells connected with the olfactory nerve fibrils. The growth of the pallium towards the paraterminal body pushes the hippocampus backwards and causes its anterior end to become rudimentary, a mere pre-commissural vestige of the part which in the reptile and amphibian made up almost the whole mesial and part of the lateral wall of the hemisphere. With this enormous growth of the governing mechanism of the pallium there is correlated a growing necessity for bilateral co-operation, and therefore an increased growth of commissural neurones. But the space through which the original pallial commissural axons (in the ventral commissure) pass is limited by the growth of the ganglionic masses of the corpus striatum and their approximation to the thalamus (wall of the fore-brain). These new axons must therefore seek a new and more direct path, and they find this along the track occupied by the fibres of the now much reduced dorsal commissure. This newly-developing pallial commissure or *corpus callosum*, which is peculiar to the eutherian brain, is quite distinct from the hippocampal dorsal commissure, whose place it to some extent takes, and which it exceeds in size in proportion to the predominance of the pallium over the hippocampus. A portion of the paraterminal body is intercepted between the corpus callosum and the fornix, becoming the septum lucidum (vol. i. p. 876), which is thus not pallial but paraterminal in its nature. A fissure which runs from the margin of the olfactory bulb to the genu of the corpus callosum is the real boundary of the pallium, and the band which borders this furrow above, the gyrus sub-callosus, is also a surviving part of the paraterminal body. The ventral commissure, which continues to carry the uniting axons of the pyriform tubercle and olfactory bulb, is separated in the human brain by the anterior commissure. From these the pallial fibres which accompanied them in the marsupials as the most dorsal band of the ventral commissure have in the eutheria followed in their increase a course of least resistance and occupied the space vacated by the recession of the hippocampi. This change is foreshadowed in the brains of diprotodont marsupials by the separation of this band of the anterior commissure from the rest and its passing to the pallium through the internal capsule, as if to relieve the tension of the area of the anterior commissure.

The convolutioning of the surface of the adult cerebral hemisphere has been described at length in vol. i. p. 873. These convolutions are folds produced by the enormous growth of the grey surface of the pallium, and first appear about the fourth month of fœtal life. Arnold and others have described a series of transitory fissures which they supposed to arise and to become obliterated before the growth of the permanent set, but these have been shown to be the result of accident and reagents by Hochstetter and Elliot Smith. (For further particulars concerning the cerebrum see Cunningham, *Trans. Royal Irish Acad.* 1892, and the numerous papers in the *Journal of Anatomy* by Elliot Smith, 1898-1901. For the visceral nerves and their courses see Harman's papers, *Journal of Anat.* 1898, 1899, 1900. For views as to the general constitution of a nerve see Gaskell, *Journ. of Physiol.* 1886. For the distribution of sensory nerves see Head, *Brain*, 1893-94. The anatomy of the sense organs has been sufficiently treated in *Ency. Brit.* vol. i. pp. 884-899. An excellent account of recent work on the subject is given by Schafer in *Quain's Anat.* iii. 1894.)

IV. *Organs of Assimilation.*—From appearances presented in the early stages of the vertebrate embryo, it is probable that there were two preceding forms of alimentary canal which were functional at different periods in the archaic ancestry of the group before the evolution of the existing or hypoblastic digestive organs. Of the earlier a vestige remains in the central canal of the spinal cord; of the second the notochord is possibly a trace. When the hypoblastic digestive canal becomes closed in, it has at first no communication with the outer surface, being closed both at the head and tail ends; but within the first few weeks of existence two superficial pits form, one on the ventral side of the fore-brain region and one on the ventral side of the tail. These, too, by the rupture of the membranes which separate them from the gut become respectively the mouth and the cloacal opening. The former of these pits is called the *stomodæum*, and gives rise to the cheeks and lips, the alveolar arches, and the nasal passages. In it the palate arises as a horizontal partition, which grows from each side across its cavity, dividing the nasal from the oral cavity. Sometimes this partition fails to unite with its fellow in the middle line, giving rise to the malformation called cleft palate. The bottom part of the pouch of the stomodæum projects through the tissue which is forming the base of the skull, and fuses with the hypophysis to form the pituitary body.

Mouth.

The *pharynx* (see vol. vii. p. 222) is the part of the alimentary canal which lies in front of the continuous cœlomic cavity, having on each side of it the remains of the primitive upper aortic arches, which in man have become the carotid arteries. It was in early embryonic life the region of visceral clefts like those which persist in fishes, but these disappear in man, except the first, which remains as the outer ear passage and the Eustachian tube. The *teeth*, described in vol. vii. p. 232, are papillæ of the same order as those of the skin, only differentiated because they are more discrete, larger, and arise on the dermis covering the jaw arches. Investigators are not agreed as to the nature of heterodontism—some (Osborn and Cope) teaching that the multituberculate molar has originated from the development of secondary tubercles on an originally simple protocone. Others, like Röse, believe the compound teeth to arise from the fusion of several papillæ. The balance of evidence is in favour of the latter view. Some mammals, such as the porpoise and other toothed whales, have but one dentition of homodont teeth; these are all animals with long narrow jaws and simple dental papillæ. In others, which are heterodont, all the first set persist together with several premolars of a secondary set. In others the milk set of teeth are replaced; but the permanent molars, which are the latest part of the primary dentition, persist and are not replaced, as in man. Man is descended from mammals which had three incisors on each side of each jaw, and three premolars. In all the primates, however, the lateral incisor has aborted, leaving only two; and likewise the hindmost of the premolars has generally vanished, although a rudimental tooth in this position has been described by Fraser as a not uncommon anomaly among black races (*Proc. Camb. Philos. Soc.* 1900). In the lower races of mankind the teeth are large, and this can be measured by the comparison of the length of the five molar teeth with that of the basicranial axis. The former is over 44 per cent. of the latter in the black races; under 42 per cent. in the whites. The human soft palate has a *uvula* (vol. vii. p. 223), which is absent in most mammals. This pendant acts as a sentinel at the passage from the mouth to the pharynx, and is needed because of the upright position of man and because in him the glottis, or top of the air passage, is not prolonged up so as to project into the nasal region of the pharynx above the velum, as it is in the majority of animals.

Concerning other parts of the digestive canal, further research on the œsophagus will be found in the papers of Birmingham, *Journal of Anat.* xxxiii. p. 10, and Strahl, *Arch. f. Anat. u. Phys.* 1889. For the minute structure of the stomach, see Langley, *Journal of Phys.* 1882, and Müller, *Verhandl. d. biol. Verein*, Stockholm, 1891-92. For a discussion on the position of the stomach, see Lesshaft in Virchow's *Archiv*, 1882. On the cæcum see Treves, *Hunterian Lectures*, 1885. Recent descriptions of the structure of the villi of the small intestine will be found in Paneth, *Arch. f. mikrosp. Anat.* 1888; and on the study of the pancreas see Podrwyszotzky, *Arch. f. mikrosp. Anat.* 1882. The lobes of the liver and their embryonic relations have been described by Thomson, *Journ. of Anat.* xxxiii. p. 546; on the structure of the liver see Retzius, *Biol. Untersuch.*, Stockholm, 1892, and Shore, *Journ. of Physiol.* 1889.

Intestine.

In the fœtal intestine the duct of the umbilical vesicle communicated with the region which becomes in the adult the lower part of the small intestine. In general it disappears completely, but occasionally the terminal part of the duct persists as a short blind tube which is called *Meckel's diverticulum*. The differentiation of the lower end of the alimentary canal as a large intestine begins in the lower vertebrates. That part which in the quadruped is lowest and most depending becomes distended by the accumulation of waste or fæcal materials, and when this differentiation is established, the beginning of the large gut is usually marked by the development of a blind pouch or *cæcum*. In the human embryo this is a tapering conical sac, but when, after the assumption of the upright position, the cæcum changes its position and sinks down on the right side into the iliac fossa, the base of this becomes distended and is called the cæcum, while the originally fusiform extremity narrows and becomes the *vermiform appendix* (Fig. 9), often the seat of a painful and dangerous inflammatory process—another of the penalties we pay for the advantage of the upright position.

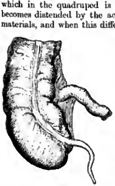


FIG. 9.—Cæcum and vermiform appendix of human intestine.

Ductless glands.

A series of peculiar glandular masses in the body differ from the true secreting glands in having no separate ducts. It is generally believed that these pour their secretions directly into the blood, and it is certain that in most cases disease or ablation of these organs produces specific effects on the composition of the blood and on local nutrition. These organs are (1) the *spleen* (vol. i. p. 907), whose essential structure (Fig. 10) consists of a mass of adenoid connective tissue, with a fibro-muscular capsule, into whose meshes capillary and other blood-vessels open (a good description of its tissue is given by Klein, *Quart. Journ. of Micros. Sc.* 1875); (2) the *thyroid* body, which arises as a diverticulum from the fourth branchial cleft on each side and medially from the fundus of a pouch whose opening remains in vestige on the back of the tongue, as in the *foramen cæcum*. It consists essentially of a number of closed follicles lined with epithelium, embedded in a vascular connective-tissue matrix (see Baber, *Phil. Trans.* 1876; Biondi, *Archiv. Ital. de Biol.* 1892). (3) Embedded in the thyroid are the *parathyroid* bodies, of which there are two on each side, differing in the details of structure from the thyroid (see Welsh, *Journ. of Anat.* xxxii. 292). (4) The thymus, transitory in man, but persistent in other animals, is derived from a diverticulum of the third branchial cleft (see Watney, *Phil. Trans.* 1882; and Symington, *Journ. of Anat.* xxxii. 278). (5) The *suprarenal body*, placed above and on the inner side of the kidney. (For its structure see Rolleston, and for the development, Minot, *Embryology*, p. 485.) (6) The *pituitary* body above the body of the sphenoid is formed partly from the end of the infundibulum of the brain and partly from the fundus of the stomodæum. For its structure see Schönemann in Virchow's *Archiv*, 1892. Other structures of the kind which are rudimentary in man are (7) the *carotid gland*, and (8) the *coccygeal body*. (Described by Luschka, Virchow's *Archiv*, 1860; Reichert's *Archiv*, 1862; and Schaper, Schultze's *Archiv*, 1892. See also Arnold, Virchow's *Archiv*, 1866.) The *hæmolymph glands* which lie in the hilum of the kidney are also structures of this class. (See Drummond, *Journ. of Anat.* 1900.)

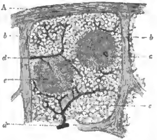


FIG. 10.—Section of the spleen, seen under a low power. A, fibrous capsule; *b*, trabeculæ; *c*, Malpighian corpuscles; *d*, blood-vessels; *e*, spleen-pulp.

V. The *vascular system* has been described in vol. i. p. 899, and most additions to our knowledge have been in matters of detail. The development of the heart has been revised by Born. The morphology of the venous system has been carefully studied in detail by Hochstetter (*Anat. Anz.* 1887-88; *Morpholog. Jahrb.* 1891). For the arterial system see Eichholz in *Journ. of Anat.* 1895, and Mackay, *Proc. Philos. Soc. Glasgow*, 1887.

Blood.

The histological elements of blood are described in vol. i. p. 845. It has since been shown that white corpuscles do not constitute a homogeneous category, but under this name at least six diverse forms are present in healthy blood. The points of difference are size, shape, and disposition of nucleus; nature of cell reticulum; and composition of the contained granules as shown by their different reactions with staining media. The following are the chief varieties:—

(1) About 70 per cent. of the corpuscles have polymorphic, many-lobed nuclei which often seem to break up into three or four distinct masses (hence these have been named *polynuclear*). The cells are moderately large and stain readily, the protoplasm reacting to acid stains while the granules are neutrophile. (2) About 2 per cent. of corpuscles, similar to the last in most aspects, differ by containing a peripheral stratum of granules which stain deeply with eosin. (3) About 1 per cent. are mononuclear, of much larger size, the single nucleus being large, oval, and eccentric; the protoplasm is free from granules and weakly basophile. (4) About 4 per cent. of the total are intermediate in characters between those of the first and third orders; they are smaller than the typical mononuclear leucocytes, and have a bilobed nucleus which stains more

deeply than that of the last group. Neutrophile granules are sparingly present in the protoplasm. (5) A very small number (less than 0·5 per cent.) are sharply marked off from the first order by possessing intensely basophile granules unequal in size and irregular in distribution; when acted on by certain stains they exhibit tints characteristically different from those which the same stains produce in other corpuscles. (6) Lymphocytes (about 23 per cent.) are bodies quite distinct from any of the foregoing orders. They are small, about the size of red corpuscles, and contain a large round nucleus, marked as if made of concentric layers, and staining uniformly. It is surrounded by a thin protoplasmic layer whose reticular structure is easily brought out by basic stains. The discrimination of these various forms and their abnormal modifications is regarded as important in modern pathology (see Ehrlich-Lazarus, *Anæmie*. Vienna, 1898, pt. 1.)

VI. *Eliminative Organs.*—The urinary and reproductive organs are inseparably united in man as in all vertebrates. The former consist of the *kidneys* and their ducts—the *ureters*, the *urinary bladder*, and the *urethra*. The latter, in the male, of the *testes*, *vesiculæ seminales*, *vasa deferentia*, and the *prostatic* and *anteprostatic glands*. In the female the organs are *ovary*, *Fallopian tube*, *uterus*, and *vagina*, and the several folds which bound the vaginal opening. There is embryological evidence that the kidneys are specialized organs which have originated at a comparatively late period of vertebrate phylogeny. In the elementary condition of urogenital organs found in segmented invertebrates the sex-gland is only a specialized area of the lining epithelium of the cœlom (vol. xx. p. 408), and the sex-products, ova or spermatozoa, arising from the germinal epithelium are shed into the body cavity. A communication between the body cavity and the surrounding medium exists in the form of a segmental tube or nephridium on each side of each segment. These are not only the channels of escape of the sex-products, but are also, in general, excretory organs. In the earlier stages of the lower vertebrates the presence of segmental nephridia can be demonstrated, one portion, a head-kidney or pronephros, arising in some of the anterior segments, and a second, or mesonephros, in the segments at a level farther back. These segmental tubules open internally into the cœlom and outwardly into a lateral canal which runs longitudinally and ends posteriorly by opening into the cloaca. The longitudinal tube connected with the pronephros is known as the pronephric or Müllerian duct, that connected with the mesonephros or Wolffian body is named the mesonephric or Wolffian duct. In man, as in all the amniota, there arises at an early period of development a third group of nephridial tubules, the metanephric, which by their aggregation make up the metanephros or kidney. That these are the result of a high degree of specialization is obvious from the fact that, while in the cases of the pronephros and mesonephros the nephridia and the longitudinal ducts arise independently and unite after they have attained a considerable degree of development, in the metanephros the tubules are from the first offsets from the metanephric duct or ureter, which itself arises as an offset from the mesonephric duct. In man there is never any trace of a pronephros, but the pronephric duct is distinct. The mesonephric tubules rapidly lose all traces of their secreting portions, and appear only as a vestigial structure, rudimentary in the female; but they become in the male specialized as channels for the transmission of the sex-products. The *kidneys* are two bean-shaped granular masses, firm in consistence and reddish-brown in colour, about 4½ inches long, and placed obliquely behind the other abdominal viscera—one on each side of the last thoracic and three upper lumbar vertebræ. Each is imperfectly covered on its ventral surface by peritoneum, and is moulded to some extent by the viscera which press on it. Around them there is usually a considerable amount of fat and areolar tissue, by which as well as by the peritoneum and by the presence of the surrounding viscera, the kidneys are retained in their place. In rare cases the kidney may slip from its usual place in the loins to a lower position, and may even be movable in the abdominal cavity—a condition often productive of serious consequences. The kidney in the fœtus is lobulated, but the intervals between the lobes become smoothed out in later years of childhood. Each gland is invested by a firm, closely-adherent, fibrous capsule, under which is an imperfect lamina of unstriped muscle. The inner and ventral margin of each kidney is concave, and into this *hilum* or concavity the renal artery from the aorta passes. Here also the renal vein escapes and joins the vena cava inferior. The ureter or metanephric duct, always behind and below the blood vessels, emerges here and passes backwards to the bladder. When the kidney is longitudinally divided from hilum to outer edge, the cut surface is seen to consist of two parts—an outer cortical layer, and an inner or medullary mass (Fig. 11). The latter consists of a series of eight to sixteen

Kidneys.

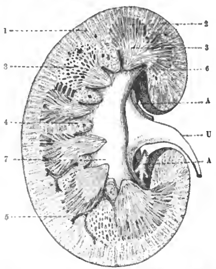


Fig. 11.—Vertical section through the kidney. A, branch of renal artery; U, ureter. 1, cortical substance with cortical pyramids, and labyrinth substance of tortuous tubes; 2 and 3, medullary pyramids of straight tubules; 4, fatty masses around blood-vessels (5); 6, papilla; 7, pelvis.

pyramids, whose bases and sides are invested with cortical matter and whose apices or papillæ project into the hilum, where they are severally surrounded by membranous tubes (calyces), which by their union make up the ureter. The part of the ureter situated in the hilum is dilated, and is named the pelvis of the kidney.

In minute structure the kidney is the most complex gland in the body. Each of the papillæ consists of a large number of straight tubes which open by pores on its surface. When these are traced into the pyramid they are seen to divide several times, their fine end-branches projecting in little tufts into the cortical matter at the base of each pyramid. Here the branches coming from the tube change in structure and become convoluted in the cortex. Next, each suddenly dips back again as a long straight loop into the pyramid, reaching nearly to the papillary region; then turning sharply on itself, passes back straight to the cortex, where it again becomes convoluted, ultimately ending by dilating into a flask-like bulb. The renal artery, after breaking up into branches between the pyramids, ends in minute end-arteries in the cortex. Each of these pierces into one of the flasks just described, and there becomes branched, the branches being collected into a little ball or glomerulus which nearly fills the flask. From this an efferent vessel escapes, which, joining with its neighbouring vessels of the same kind, makes a close network around the convoluted tubes, ultimately ending in the renal vein. It is supposed that the different constituents of the urine are eliminated in different parts of these tubes—some, especially the watery parts, in the flask, and some, especially the more solid constituents, in the convoluted tubular apparatus. A peculiar form of glandular epithelium lines the two convoluted areas of the tubes, and the limb of the loop nearer the straight or collecting tubes.

The *ureter* or duct of the kidney begins at the hilum and descends on the back wall of the abdominal cavity to open into the bladder. It is usually about 12 inches in length and as thick as a goose quill. At its termination it passes obliquely through the coats of the bladder, so that when the bladder is distended the lumen of its end is closed. The *urinary bladder* is a membranous bag lying in the pelvic cavity directly behind and above the dorsal surface of the pubes. In the fœtus and infant, however, the bladder lies in the abdomen, not in the pelvis. During life it is seldom distended so as to hold more than about 10 oz., but when the abdomen is opened it can be dilated to more than double that size. When distended it rises and is applied closely against the back of the ventral abdominal wall. The bladder has a strong muscular investment of unstriped muscle in several layers, which are innervated by branches from the sacral nerves. It has a peculiar epithelial lining of several strata, the superficial cells of which are cubical when the sac is collapsed, but become flattened and scale-like when it is distended. The bladder is developed from the portion of the sac of the embryonic allantois, which is in contact with the cloaca. The two ureters open by small oblique apertures into its base, closely behind the opening of the urethra. The *urethra* or excretory channel from the bladder is a narrow tube, $8\frac{1}{2}$ inches long in the male, whose walls are in apposition except when fluid is passing along it. It begins at the lowest part of the bladder and for its first inch and quarter passes through the prostate gland and is directed vertically downwards. The hinder wall of this portion is raised into a ridge, the *colliculus seminalis*, on each side of which the seminal ducts open. The second part is membranous, about $\frac{3}{4}$ inch in length, and directed forwards below the pubes, where it is fixed by passing through the triangular interpubic ligament. The third part is that which lies in the penis, and it is surrounded below and laterally by an erectile enveloping body, the *corpus spongiosum urethræ*. This body begins behind in a thickening, the *bulb* of the urethra, and ends in the *glans penis*, which is perforated by the urethra. Above the urethra in this stage lie the two *corpora cavernosa penis*. The urethral orifice is usually the narrowest part of the canal. The female urethra is only $1\frac{1}{2}$ inch in length, and is comparable only with that part of the male urethra which extends from the bladder to the openings of the seminal ducts (Fig. 12).

Bladder and urethra.

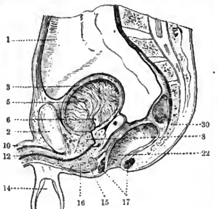


FIG. 12.—Vertical section through pelvis, showing urinary bladder and rectum *in situ*. 1, peritoneum; 2, pubic symphysis; 3, muscular coat of bladder; 5, mucous membrane folded and wrinkled; 6, opening of ureter; 8, prostate; 10, vena dorsalis penis; 12, corpus spongiosum; 14, testis in its sac; 15, bulbocavernosus muscle; 16, bulb; 17, sphincters of the anus; 22, anal opening; 30, coccyx; *, vesicula seminalis.

VII. *Reproductive Organs.*—In the human male these are the testes and their ducts, the latter being the modified mesonephric or Wolffian tubules and ducts of the fœtus. In the female they consist of the ovaries and the tubular system appended to them, which are formed from the modified Müllerian ducts. In each sex the tubular system which is not functional is represented in rudiment. Both ovary and testis are specializations of the area of germinal epithelium of the fœtal cœlom. In the *ovary* these germinal cells become grouped in numerous clusters, in the centre of each of which is a cavity, the *Graafian vesicle*, containing a central cell larger than the others, which is a *primitive ovum*. Each of these is about $\frac{1}{100}$th inch in diameter, and it has been computed that there are about 30,000 in each ovary of a female child at birth. These Graafian vesicles are embedded in a mass of connective tissue which is called the stroma of the ovary, the whole ovary being a small oval body about $1\frac{1}{2}$ inch long by about $\frac{1}{2}$ inch in thickness. The ovaries are placed one on each side in the pelvic cavity, each within a fold of peritoneum, called the *broad ligament*. Close to each ovary lies the open and fringed end of a duct, the *Fallopian tube*, which is contained in the upper edge of the broad ligament and directed inwards to open into the *uterus*. This is a pyriform organ lying in the middle of the pelvic cavity, having the bladder on its ventral aspect, the rectum on its dorsal, and the two broad ligaments one on each side. The uterus, when not containing a fœtus, is about 3 inches in length, nearly 2 inches in breadth, and 1 inch in thickness. It has a very thick wall, mostly made up of unstriped muscle, and a very small cavity which appears somewhat triangular in vertical section. Its lateral basal angles are at the openings whereby the Fallopian tubes communicate with it, and its apical inferior angle is at the neck or *cervix uteri*. This cervix projects into the upper part of the vagina, which is a membranous passage that opens on the surface. The uterus and Fallopian tubes are modifications of the Müllerian ducts and of the part of the cloaca into which these ducts open. The vagina and the folds which surround its external opening are the modifications of the urogenital sinus and its marginal folds to be referred to below.

Female.

The ova are during mature life periodically shed by rupture of the Graafian follicles when these become ripe. These are received into the open mouths of the Fallopian tubes, by which canals they are conducted into the uterus, where if fertilized they develop, but if not fertilized they are extruded. Before fertilization each ovum undergoes a process of cell division by which it extrudes a portion of its nuclear substance and particularly a portion of its chromosomes. The act of fertilization consists in the reception by the ovum of certain nuclear masses, including chromosomatic substance, which unites with the nuclear substance and chromosomes of the ovum to form a new complete nucleus.

Male.

The *testis* or male sex gland is also developed from the germinal area of the cœlom. Nests of cells derived from the germinal epithelium become clustered and surrounded with a stroma of mesoblast into which the Wolffian tubules penetrate, ultimately becoming a tubular system, whose terminal roots enclose the cell nests as a lining epithelium. When first formed the testes lie in the lumbar region of the fœtal abdomen above and internal to the kidneys, but from this site they begin to migrate about four months before birth. They reach the abdominal wall in the groin in two months, and there each passes through an oblique canal (the *inguinal canal*) in the muscular and fibrous wall of the abdomen and descends into the scrotum, which is a loose bag of skin formed by the lateral lips of the urogenital sinus (which long before this period have united medially). This descent is generally completed a month before birth. Along with the testis a tubular pouch of the serous lining of the abdomen is prolonged into the scrotum, which, when the descent is complete, becomes obliterated at the place where it traverses the abdominal wall, though remaining below as an envelope of the testis. The region of the inguinal canal is always the weakest spot in the abdominal wall, and it is along the track of the descended testis that those protrusions of the abdominal viscera, called *herniæ*, are most liable to occur. As it is the assumption of the upright position which places the inguinal canal at the lowest part of the abdomen, this tendency to hernia is another of the penalties which man pays for the advantages of a bipedal progression.

The testis in the adult is made up of a great mass of convoluted tubules arranged in about 200 lobules, and the whole mass is included in a tough fibrous tunic. The lining epithelium of these seminal tubes by a special method of cell division gives rise to the male elements or spermatozoa, which are minute thread-like bodies consisting of a small oval head, about $\frac{1}{5000}$th inch long, a slender middle-piece nearly as long, and a hair-like flagellum or tail tapering to a fine point and measuring $\frac{1}{500}$th inch. The tubular system whereby these and the fluid in which they float are conveyed away is derived from the Wolffian tubules, which open into the Wolffian duct, now called *vas deferens*. Owing to the new position assumed by the testis, this duct has to ascend from the scrotum, to pass through the inguinal canal, and then to descend into the pelvic cavity in order to gain the first part of the urethra, into which it opens. Close to the urethral extremity of each vas deferens, and on its outer side is an irregularly pyriform pouch, the *vesicula seminalis*, to store the secretion from the testis.

Differentiation of external sex organs.

In early fœtal life the terminal openings of all the excretory tubes—intestinal, urinary, and genital—unite and reach the surface by a single slit-like orifice. This condition, which is persistent in the monotremata and lower vertebrates, is transitory in man and the higher mammals. When first formed, the hinder end of the gut, with its appended allantois, has no external aperture, but at an early date in the embryonic history a pit of the surface integument, which is named the *proctodæum*, dips in on the ventral side of the vertebral column, and its bottom layer comes in contact with the gut close to its extreme blind end. Soon the membrane separating this pit from the gut ruptures, and the *cloaca* is formed. During the second month of fœtal life a transverse ridge, formed by a downgrowth of the ventral wall of the lower end of the gut, shuts off the allantois from the intestine and divides the cloaca into a ventral or *urogenital region*, and a dorsal or *anal*. By the third month this partition has thickened into a definite band of integument which is called the *perinæum*. The urogenital sinus is a slit-like space into which open the allantois, the Wolffian and Müllerian ducts and the ureters. At the ventral end of its aperture an eminence, the *tuberculum genitale*, rises, deeply grooved on its dorsal surface; and from the lower edge of each lip of the groove a marginal *vestibular ridge* descends on each side of the opening of the sinus to unite with its fellow at its dorsal extremity. On each side, external to this vestibular ridge, the skin at the margin of the urogenital sinus forms a prominent lip, making the opening appear as a longitudinal fissure. So far the process of development is identical in the two sexes, but at this point differentiation occurs. In the female the tuberculum genitale becomes the clitoris, and the vestibular and marginal folds respectively the labia majora and minora. In the male the vestibular folds unite in the median line, except at their ventral extremity, thus closing in the canal which forms the second and third parts of the urethra, and in the combined under-wall thus constituted erectile tissue develops, forming the corpus spongiosum urethræ above described. The terminal ventral opening becomes the meatus urinarius. The two cutaneous outer lips also fuse together medially, making the scrotum. The bilateral tuberculum genitale becomes by the development of erectile tissue the corpora cavernosa penis. In each sex the tubular system which does not become functional leaves vestiges which discharge no function. In the female the Wolffian tubules remain as a series of linear streaks in the substance of the broad ligament, the *epoophoron*. In the male the Müllerian ducts leave two vestiges, a minute saccule appended to the top of the testis, and a minute pouch, the *sinus pocularis*, in the colliculus seminalis of the urethra. This latter corresponds to the cavity of the uterus in the female, a correspondence which is rendered more striking as this pouch and the adjoining portion of the urethra are surrounded by a mass of unstriped muscle, with some gland tubes included in it, to which the name *prostate* is given. This organ is about the size and shape of a chestnut.

Variability of the Human Body.

No two human bodies are alike in their organization, and there is no organ in the body which is not liable to vary. Some parts, however, are especially liable to abnormalities, more especially those which have the most complicated developmental history, those which derive their origin from more than one component, which pass through several stages and are late in arriving at their full development. Of those organs which occur in series, the terminal members are more variable than the intermediate. Organs do not vary indifferently in every direction; there are some conceivable forms of variety which never occur, others which are common. Nor can variations be reduced to a continuous series. Some of them are sudden breaks, between which and the normal no intermediate links are known.

Most varieties are individualistic, depending on conditions of nutrition or environing circumstances affecting development. A few, such as the development of a third incisor or third premolar, seem to be atavistic, but atavism has been invoked in many cases to which it does not apply. The vascular system is the most, and the nervous the least, variable. The muscular and skeletal systems occupy intermediate positions. The literature of anomalies is very large. The general subject is dealt with in the *Robert*

Boyle Lecture, Oxford, 1894; see also MONSTER (*Ency. Brit.* vol. xvi. p. 762) and Bateson, *Materials for the Study of Variation*, 1895.

History of Anatomy.—To the detailed history given in vol. i. pp. 799 *et seqq.*, it is only necessary to add that recent researches on the early history of anatomy will be found in the several articles entitled "Archæologia Anatomica" in the *Journal of Anatomy* for 1898, 1899, and 1900. (A. MA.)

Anatomy of Plants.

The term "Anatomy," originally employed in biological science to denote a description of the facts of structure revealed on cutting up an organism, whether with or without the aid of lenses for the purpose of magnification, is restricted in the present article, in accordance with a common modern use, to those facts of internal structure not concerned with the constitution of the individual *cell*, the structural unit of which the plant is composed. For a description of the cell itself, the article CYTOLOGY must be consulted. In all but the very simplest forms the plant-body is built up of a number of these cells, associated in more or less definite ways. In the higher (more complicated) forms the cells differ very much among themselves, and the body is composed of definite systems of these units, each system with its own characteristic structure, depending partly on the characters of the component cells and partly on the method of association. Such a system is called a *tissue-system*, the word tissue being employed for any collection of cells with common structural, developmental, or functional characters to which it may be conveniently applied. The word is derived from the general resemblance in the texture of plant substance to that of a textile fabric, and dates from a period when the fundamental constitution of this substance from individual cells was not yet discovered. The study of tissues is known as *Histology*, and it is with this that the present article is necessarily mainly concerned. The method of treatment will be evolutionary; that is to say, an endeavour will be made to trace the gradual steps through which the more complicated tissue-systems of the various groups of plants have been developed from simple cell-collections, during that descent of the more complicated from the simpler plants which constitutes the fundamental postulate of the comparative study of form in modern biology. The terms *morphology* and *morphological* will be used throughout wherever such comparative consideration with this evolutionary implication is involved. It must be understood, however, that the evolution of form is invariably governed by the vital needs of the organism, so that a consideration of the vital relations of the plant to its surroundings, and of the actions and functional relations of its organs and tissues, is an indispensable condition of the construction of a real and intelligible morphology. In this way our outline of *morphological* anatomy will involve an outline of *physiological* anatomy.

It will easily be realized that since the plant-body consists entirely of tissues, through which all its functions are performed, an account of the evolution of plant-tissues is nearly equivalent to an account of the evolution of plants. Our task will be simplified, however, by the omission of direct reference to the tissues of the specialized reproductive organs, for which the reader is referred to the articles on the different groups of plants. Even so it must be apparent that in the present article nothing but the barest sketch of the subject, in which much is left out and many topics are treated dogmatically, is at all possible. The articles BOTANY (*Ency. Brit.* vol. iv. pp. 85-93, and 99-108), and HISTOLOGY, VEGETABLE (vol. xii.), give good general accounts of the nature of vegetable tissues, particularly in the flowering plants, and in the former are many figures, for the most part admirable, illustrating histological structure, which the reader may consult with advantage. Much of the terminology and some of the descriptions are, it is true, out of date, a result that must always soon occur in a very rapidly advancing branch of science, as plant anatomy was twenty years ago. The morphological point of view, as sketched above, has been fully applied to plant-tissues only in very recent years, so that in an article of earlier date it is only natural that the provisional nature of descriptive terminology should become very apparent after the lapse of a few years.

An account of the structure of plants naturally begins with the *cell*, which is the proximate unit of organic structure. The cell is essentially an individualized mass of protoplasm containing a differentiated protoplasmic body, called a *nucleus*. But all cells which are permanent tissue-elements of the plant-body possess, in addition, a more or less rigid limiting membrane or *cell-wall*, consisting primarily of cellulose or some allied substance. It is the cell-walls which connect the different cells of a tissue, and it is upon their characters (thickness, sculpture, and constitution) that the qualities of the tissue largely depend. In many cases, indeed, after the completion of the cell-wall (which is secreted by the living cell-body) the protoplasm dies, and a tissue in which this has occurred consists solely of the dead framework of cell-walls, enclosing in the cavities or *lumina* originally occupied by the protoplasm simply water or air. In such cases the characters of the adult tissue clearly depend solely upon the characters of the cell-walls, and it is usual in plant anatomy to speak of the wall with its enclosed cavity as "the cell," and the contained protoplasm or other substances, if present, as *cell-contents*. This is in accordance with the original use of the term "cell," which was applied in the 17th century to the cavities of plant-tissues on the analogy of the cells of honeycomb. The use of the term to mean the individualized nucleated mass of living protoplasm, which, whether with or without a limiting membrane, forms primitively the proximate histological element of the body of every organism, dates from the second quarter of the 19th century. We proceed to a systematic account of the anatomy of the different groups of plants, beginning with the simplest, and passing to the more complicated forms.

Thallophyta.

The simplest members of both the Algæ and the Fungi (*q.v.*), the two divisions of the *Thallophyta*, the lowest of the four great groups into which the plant-kingdom is divided, have their bodies each composed of a single cell. In the Algæ such a cell consists essentially of—(1) a mass of protoplasm provided with (2) a nucleus; and (3) an assimilating apparatus consisting of a coloured protoplasmic body, called a *chromatophore*, the pigment of which in the pure green forms is chlorophyll, and which may then be called a *chloroplast*. The whole is covered by the cell-membrane (Fig. 1 A). It is from such a living and assimilating cell, performing as it does all the vital functions of a green plant, that, according to current theory, all the different cell-forms of a higher plant have been differentiated in the course of descent.

Cell and tissue differentiation in Algæ.

Among the Green Algæ the differentiation of cells is comparatively slight. Many forms, even when multicellular, have all their cells identical in structure and function, and are often spoken of as "physiologically unicellular." The cells are commonly joined end to end in simple or branched filaments. Such differentiation as exists in the higher types mainly takes two directions. In the fixed forms, the cell or cells which attach the plant to the substratum often have a peculiar form, containing less chlorophyll, and constituting a rudimentary fixing organ or *rhizoid* (Fig. 1 C). In certain types living on damp soil, the rhizoids penetrate the substratum, and in addition to fixing the plant absorb food substances (dissolved salts) from the substratum (*Œdocladium*, Fig. 1 D).

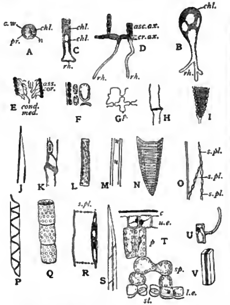


Fig. 1.—Examples of the Differentiation of Tissue in Plants.

A, Cell (individual) of the unicellular Green Alga *Pleurococcus*, as an example of an undifferentiated autonomous assimilating cell. *pr.*, Cell protoplasm; *n.*, nucleus; *chl.*, chloroplast; *c.w.*, cell-wall.

B, Plant of the primitive Siphoneous Green Alga *Protosiphon botryoides*. The primitive cell sends colourless tubelets (rhizoids, *rh.*) into the mud on which it grows. The subaerial part is tubular or ovoid, and contains the chloroplast (*chl.*). There are several nuclei.

C, Base of the multicellular filamentous Green Alga *Chætomorpha ærea*. The basal cell has less chlorophyll than the others, and is expanded and fixed firmly to the rock on which the plant grows by the basal surface, *rh.*, thus forming a rudimentary rhizoid.

D, Part of branched filamentous thallus of the multicellular Green Alga *Œdocladium protonema*. *cr. ax.*, Green axis creeping on the surface of damp soil; *rh.*, colourless rhizoids penetrating the soil; *asc. ax.*, ascending axes of green cells.

E, Vertical section of frond of the complicated Siphoneous Green Alga *Halimeda*. The substance of the frond is made up by a single much-branched tube, with interwoven branches. *cond. med.*, Longitudinally running comparatively colourless central (medullary) branches, which conduct food substances and support the (*ass. cor.*) green assimilating cortical branches, which are the ends of branches from the medulla and fit tightly together, forming the continuous surface of the plant.

F, Section through the surface tissue of the Brown Alga *Cutleria multifida*, showing the surface layer of assimilating cells densely packed with phæoplasts. The layers below have progressively fewer of these, the central cells being quite colourless.

G, Section showing thick-walled cells of cortex in Brown Alga (seaweed). Simple pits (*p.*) enable conduction to take place readily from one to another.

H, Two adjacent cells (leptoids) of a food-conducting strand in *Fucus* (a Brown seaweed). The wall between them is perforated, giving passage to coarse strands of protoplasm.

I, End of hydroid of the thalloid Liverwort *Pallavicinia*, showing the thick lignified wall penetrated by simple pits.

J, End of hydroid of the Moss *Mnium*, showing particularly thin oblique end-wall. No pits.

K, Optical section of two adjacent leptoids of the Moss *Polytrichum juniperinum*. The leptoids are living and nucleated. They bulge in the neighbourhood of the very thin cross-wall. Note resemblance to *H* and *R*.

L, Optical section of cell of conducting parenchyma in the same moss. Embedded in the protoplasm are a number of starch grains.

M, Part of elongated stereid of a Moss. Note thick walls and oblique slit-like pits, with opposite inclination on the two sides of the cell.

N, One side of end of hydroid (tracheid) of Pteridophyte, with scalariform pits.

O, Optical section of two adjacent leptoids (sieve-tube segments) of Pteridophyte, with sieve plates (*s. pl.*) on oblique end-wall and side-walls.

P, Part of spiral hydroid (tracheid) of Phanerogam.

Q. Three segments of a "pitted" vessel of Phanerogam.

R, Optical section of leptoid (sieve-tube segment) of Phanerogam, with two proteid (companion) cells. *s. pl.*, sieve-plate.

S, Optical section of part of thick-walled stereid of Phanerogam, with almost obliterated cavity and narrow slit-like oblique pits.

T, Part of vertical section through blade of typical leaf of Phanerogam. *u.e.*, Upper epidermal cells, with (*c*) cuticle, (*p.*) assimilating (palisade) cells. *sp.*, Assimilating (spongy) cells, with large lacunæ. *l.e.*, Lower epidermis, with *st.*, stoma.

U, Absorbing cell, with process (root-hair) from piliferous layer of root of Phanerogam.

V Endodermal cell of Phanerogam, with suberized central band on radial and transverse walls.

The second type of differentiation is that between supporting axis and assimilating appendages. The cells of the axis are commonly stouter and have much less chlorophyll than those of the appendages. This differentiation is parallel with that between stem and leaf of the higher plant. In the group of the Siphoneæ both these types of differentiation may exist in the single, long, branched, tube-like, and multinucleate cell which here forms the plant-body. *Protosiphon* (Fig. 1 B) is an example parallel with *Œdocladium*; *Bryopsis*, with *Draparnaldia*. In *Caulerpa* the imitation of a higher plant by the differentiation of fixing, supporting, and assimilating organs (root, stem, and leaf) from different branches of the single cell is strikingly complete. In the Siphoneous family of *Codiaceæ* (Fig. 1 E) the branches of the primitive cell become considerably interwoven one with another, so that a dense tissue-like structure is often produced. In this we get a further differentiation between the central tubes (branches of the primitive cell), which run in a longitudinal direction through the body, possess little or no chlorophyll, and no doubt serve to conduct food substances from one region to another, and the peripheral ones, which are directed perpendicularly to the surface of the body, ending blindly there, contain abundant chlorophyll, and are the assimilating organs.

None of the existing Red Seaweeds has a unicellular body. The thallus in all cases consists of a branched filament of cells placed end to end, as in many of the Green Algæ. Each branch grows simply by the transverse division of its apical cell. The branches may be quite free or they may be united laterally to form a solid body of more or less firm and compact consistency. This may have a radial stem-like organization, a central cell-thread giving off from every side a number of short sometimes unicellular branches, which together form a cortex round the central thread, the whole structure having a cylindrical form which only branches when one of the short cell-branches from the central thread grows out beyond the general surface and forms in its turn a new central thread, from whose cells arise new short branches. Or the thallus may have a leaf-like form, the branches from the central threads which form the midrib growing out mainly in one plane and forming a lamina, extended right and left of the midrib. Numerous variations and modifications of these forms exist. In any case, while the internal threads which bear the cortical branches consist of elongated cells with few chromatophores, and no doubt serve mainly for conduction of food substances, the superficial cells of the branches themselves are packed with chromatophores and form the chief assimilating tissue of the plant. In the bulky forms colourless branches frequently grow out from some of the cortical cells, and, pushing among the already-formed threads in a longitudinal direction, serve to strengthen the thallus by weaving its original threads together. The cells belonging to any given thread may be recognized at an early stage of growth, because each cell is connected with its neighbours belonging to the same thread by two depressions or pits, one at each end. The common wall separating the pits of the two adjoining cells is pierced by strands of protoplasm. The whole structure, consisting of the two pits and the wall between, is known as a *genetic pit*. Other pits, connecting cells not belonging to the same branch, are, however, formed at a later stage.

Many of the lower forms of Brown Seaweeds have a thallus consisting of simple or branched cell threads, as in the green and red forms. The lateral union of the branches to form a solid thallus is not, however, so common, nor is it carried to so high a pitch of elaboration as in the Rhodophyceæ. In a few of the lower forms (Sphacelariaceæ), and in the higher forms which possess a solid thallus often of very large size, the plant-body is no longer formed entirely of branched cell threads, but consists of what is called a true parenchymatous tissue, a solid mass of cells, that is to say, formed by cell division in all directions of space. In the Laminariaceæ this tissue is formed by cell division at what is called an *intercalary growing point*, *i.e.*, a *meristematic* (cell-dividing) region occupying the whole of a certain zone of the thallus, and cutting off new cells to add to the permanent tissue on both sides. In the Fucaceæ, on the other hand, there is a single prismatic *apical cell* situated at the bottom of a groove at the growing apex of the thallus, which cuts off cells from its sides to add to the peripheral, and from its base to add to the central permanent cells. The whole of the tissue of the plant is formed by the division of this apical cell. In whatever way the tissues are originally formed, however, the main features of their differentiation are the same. According to a law which applies also to the green and red forms, the superficial cells are packed with chromatophores and form the assimilating tissue. In these brown types with bodies of considerable thickness (Laminariaceæ and Fucaceæ) there is, however, a further differentiation of the internal tissues. The cells immediately subjacent to the superficial assimilating layer form a colourless, or nearly colourless, parenchymatous *cortex*, which acts as a food storage tissue, and surrounds a central *medulla* of elongated conducting cells. The latter are often swollen at the ends, so that the cross-wall separating two successive cells has a larger surface than if the cells were of uniform width along their entire length. Cells of this type are often called *trumpet-hyphæ*, and in some genera of Laminariaceæ those at the periphery of the medulla simulate the *sieve-tubes* of the higher plants in a striking degree, even developing the peculiar substance *callose* on or in the perforated cross-walls or sieve-plates. A specialized conducting tissue of this kind, used mainly for transmitting organic nitrogenous substances, is always developed in plants where the region of assimilative activity is local in the plant-body. This is the case in the Fucaceæ, and in a very marked degree in the Laminariaceæ in question, where the assimilative *frond* is borne at the end of a long supporting and conducting *stipe*. The tissue developed to meet the demands for conduction in such cases always shows some of the characters described. It is known as *leptom*, each constituent cell being a *leptoid*. In addition to the cell types described, it is a very common occurrence in these bulky forms for rhizoid-like branches of the cells to grow out mostly from the cells at the periphery of the medulla, and grow down between the cells, strengthening the whole tissue, as in the Rhodophyceæ. This process may result in a considerable thickening of the thallus. In many Laminariaceæ the thallus also grows regularly in thickness by division of its surface layer, which thus forms a *secondary meristem*.

Tissue-differentiation in Fungi.

The simpler Fungi, like the simpler Green Algæ, consist of single cells or simple or branched cell threads, but among the higher kinds a massive body is often formed, particularly in connexion with the formation of spores, and this may exhibit considerable tissue-differentiation. A characteristic feature of the fungal vegetative plant-body (*mycelium*) is its formation from independent cœnocytic tubes or cell threads. These branch, and may be packed or interwoven to form a very solid structure; but each grows in length independently of the others and retains its own individuality, though its growth in those types with a definite external form is of course correlated with that of its neighbours, and is subject to the laws governing the general form of the body. Such an independent cœnocytic branch or cell thread is called a *hypha*. Similar modes of growth occur among the Siphoneous green and also among the red seaweeds. A solid fungal body may usually be seen to consist of separate hyphæ, but in some cases these are so bent and closely interwoven that an appearance like that of ordinary parenchymatous tissue is obtained in section, the structure being called *pseudoparenchyma*. By the formation of numerous cross-walls the resemblance to parenchyma is increased. The *surface-layer* of the body in the massive Fungi differs in character according to its function, which is not constant throughout the class, as in the Algæ, because of the very various conditions of life to which different Fungi are exposed. In many forms its hyphæ are particularly thick-walled, and may strikingly resemble the epidermis of a vascular plant. This is especially the case in the lichens (symbiotic organisms composed of a fungal mycelium in association with algal cells), which are usually exposed to very severe fluctuations in external conditions. The formation of a massive body naturally involves the localization of the absorptive region, and the function of absorption (which in the simpler forms is carried out by the whole of the vegetative part of the mycelium penetrating a solid or immersed in a liquid substratum) is subserved by the outgrowth of the hyphæ of the surface-layer of that region into *rhizoids*, which, like those of the Algæ living on soil, resemble the root-hairs of the higher plants. The *internal tissue* of the body of the solid higher Fungi, particularly the elongated stalks (*stipes*) of the fructifications of the Agarics, consists of hyphæ running in a longitudinal direction, which no doubt serve for the conduction of plastic food substances, just as do the "trumpet-hyphæ," similar in appearance, though not in origin, of the higher brown seaweeds. (In one genus (*Lactarius*) "milk-tubes," recalling the laticiferous tubes of many vascular plants, are found.) These elongated hyphæ are frequently thick-walled, and in some cases form a central strand, which serves to resist longitudinal pulling strains. This is particularly marked in certain lichens of shrubby habit. The internal tissues, either consisting of obvious hyphæ or of pseudoparenchyma, may also serve as a storehouse of plastic food substances.

Looking back over the progress of form and tissue-differentiation in the Thallophyta, we find that, starting from the simplest unicellular forms with no external differentiation of the body, we can trace an increase in complexity of organization everywhere determined by the principles of the division of physiological labour and of the adaptation of the organism to the needs of its environment. In the first place there is a differentiation of fixing organs, which in forms living on a soft nutrient substratum penetrate it and become absorbing organs. Secondly, in the Algæ, which build up their own food from inorganic materials, we have a differentiation of supporting axes from assimilating appendages, and as the body increases in size and becomes a solid mass of cells or interwoven threads, a corresponding differentiation of a superficial assimilative system from the deep-lying parts. In both Algæ and Fungi the latter are primarily supporting and food-conducting, and in some bulky Brown Seaweeds where assimilation is strongly localized some of the deep cells are highly specialized for the latter function. In the higher forms a storage and a mechanically-strengthening system may also be developed, and in some aerial Fungi an *external* protective tissue. The "hyphal" mode of growth, *i.e.*, the formation of the thallus, whatever its external form, by branched, continuous or septate, cœnocytic tubes (Siphoneæ and Fungi), or by simple or branched cell threads, in both cases growing mainly or entirely at the apex of each branch, is almost universal in the group, the exceptions being met with almost entirely among the higher brown seaweeds, in which is found parenchyma produced by the segmentation of an apical cell of the whole shoot, or by cell division in some other type of meristem.

Bryophyta.

The Bryophyta, the first group of mainly terrestrial plants, exhibit considerably more advanced tissue differentiation, in response to the greater complexity in the conditions of life on land. But the lowest Hepaticæ have an extremely simple vegetative structure, little more advanced than that found in some of the higher Green Algæ and very much simpler than in the large red and brown seaweeds. The thallus, however, always consists of true parenchyma, and is entirely formed by the cutting off of segments from an apical cell.

Liver-worts.

A sufficient description of the thallus of the Liver-worts, *e.g.*, *Fegatella*, will be found in the article MUSCINEÆ (*Ency. Brit.* vol. xvii.). We may note the universal occurrence on the lower surface of the thallus of fixing and absorbing rhizoids in accordance with the terrestrial life on soil (*cf.* *Œdocladium* among the Green Algæ). The Marchantiaceæ (see article MUSCINEÆ) show considerable tissue-differentiation, possessing a distinct assimilative system of cells, consisting of branched cell threads packed with chloroplasts and arising from the basal cells of large cavities in the upper part of the thallus. These cavities are completely roofed by a layer of cells; in the centre of the roof is a pore surrounded by a ring of special cells. The whole arrangement has a strong resemblance to the lacunæ, mesophyll and stomata, which form the assimilative and transpiring (water-evaporating) apparatus in the leaves of flowering plants. The frondose (thalloid) Jungermanniaceæ show no such differentiation of an assimilating tissue, though the upper cells of the thallus usually have more chlorophyll than the rest. In three genera—*Pallavicinia*, *Symphyogyna*, and *Hymenophyton*—there are one or more strands or bundles consisting of long thick-walled fibre-like cells, pointed at the ends and running longitudinally through the thick midrib. The walls of these cells are strongly lignified (*i.e.*, consist of woody substance) and are irregularly but thickly studded with simple pits (see CYTOLOGY), which are usually arranged in spirals running round the cells, and are often elongated in the direction of the spiral (Fig. 1 I). These cells are not living in the adult state though they sometimes contain the disorganized remains of protoplasm. There is little doubt that their function is to conduct water through the thallus, the assimilating parts of which are in these forms often raised above the soil and comparatively remote from the rhizoid-bearing (water-absorbing) region. Such differentiated water-conducting cells we call *hydroids*, the tissue they form *hydrom*. The sporogonium of the liverworts is in the simpler forms simply a spore-capsule with arrangements for the development, protection, and distribution of the spores. As such it falls outside the scheme of this article, but in one small and peculiar group of these plants, the *Anthoceroteæ*, a distinct assimilating and transpiring system is found in the wall of the very long cylindrical capsule, clearly enabling the sporogonium to be largely independent of the supply of elaborated organic food from the thallus of the mother plant (the gametophyte). A richly chlorophyllous tissue with numerous intercellular spaces communicates with the exterior by stomata, strikingly similar to those of the vascular plants (see below). If the axis of such a sporogonium were prolonged downwards into the soil to form a fixing and absorptive root, the whole structure would become a physiologically independent plant, exhibiting in many though by no means all respects the leading features of the *sporophyte* or ordinary vegetative and spore-bearing individual in Pteridophytes and Phanerogams. These facts have led to the theory, plausible in many respects, of the origin of this sporophyte by descent from an Anthoceros-like sporogonium (see PTERIDOPHYTA). The facts, however, give us no warrant for asserting homology (*i.e.* identity by descent) between the tissues of an Anthocerotean sporogonium and those of the sporophyte in the higher plants.

Mosses.

In the Mosses the plant-body (gametophyte) is always separable into a radially organized, supporting and conducting axis (stem) and thin, flat, assimilating, and transpiring appendages (leaves). [For the histology of the comparatively simple but in many respects aberrant Bog-mosses (Sphagnaceæ), see MUSCINEÆ, *Ency. Brit.* vol. xvii.] The stems of the other mosses resemble one another in their main histological features. In a few cases there is a special surface or epidermal layer, but usually all the outer layers of the stem are composed of brown, thick-walled, lignified, prosenchymatous, fibre-like cells forming a peripheral *stereom* (mechanical or supporting tissue) which forms the *outer cortex*. This passes gradually into the thinner-walled parenchyma of the *inner cortex*. The whole of the cortex, stereom and parenchyma alike, is commonly living and its cells often contain starch. The centre of the stem in the forms living on soil is occupied by a strand of narrow elongated hydroids, which differ from those of the liverworts in being thin-walled, unlignified, and very seldom pitted. The hydrom strand has in most cases no connexion with the leaves, but runs straight up the stem and spreads out below the sexual organs or the foot of the sporogonium. It has been shown that it conducts water with considerable rapidity. In the stalk of the sporogonium there is a similar strand, which is of course not in direct connexion with, but continues the conduction of water from, the strand of the gametophytic axis. In the aquatic, semiaquatic, and xerophilous types, where the whole surface of the plant absorbs water, perpetually in the first two cases and during rain in the last, the hydrom strand is either much reduced or altogether absent. In accordance with the general principle already indicated, it is only where absorption is localized (*i.e.*, where the plant lives on soil from which it absorbs its main supply of water by means of its basal rhizoids) that a water-conducting (hydrom) strand is developed. The leaves of most mosses are flat plates, each consisting of a single layer of square or oblong assimilating (chlorophyllous) cells. In many cases the cells bordering the leaf are produced into teeth, and very frequently they are thick-walled so as to form a supporting rim. The centre of the leaf is often occupied by a *midrib* consisting of several layers of cells. These are elongated in the direction of the length of the leaf, are always poor in chlorophyll and form a channel for conducting the products of assimilation away from the leaf into the stem. This is the first indication of a conducting foliar strand or *leaf bundle* and forms an approach to leptom, though it is not so specialized as the leptom of the higher Phæophyceæ. Associated with the conducting parenchyma are frequently found hydroids identical in character with those of the central strand of the stem, and no doubt serving to conduct water to or from the leaf according as the latter is acting as a transpiring or water-absorbing organ. In a few cases the hydrom strand is continued into the cortex of the stem as a *leaf-trace* bundle (the anatomically demonstrable *trace* of the leaf in the stem). This in several cases runs vertically downwards for some distance in the outer cortex, and ends blindly—the lower end or the whole of the trace being band-shaped or star-shaped so as to present a large surface for the absorption of water from the adjacent cortical cells. In other cases the trace passes inwards and joins the central hydrom strand, so that a connected water-conducting system between stem and leaf is established.

In the highest family of mosses, Polytrichaceæ, the differentiation of conducting tissue reaches a decidedly higher level. In addition to the water-conducting tissue or *hydrom* there is a well-developed tissue inferred to be a conducting channel for nitrogenous substances or *leptom*, not indeed so highly differentiated as in the most advanced Laminariaceæ, but showing some of the characters of sieve-tubes with great distinctness. Each leptoid is an elongated living cell with nucleus and a thin layer of protoplasm lining the wall. The whole cavity of the cell is sometimes stuffed with proteid contents. The end of the cell is slightly swollen, fitting on to the similar swollen end of the next leptoid of the row exactly after the fashion of a trumpet-hypha. The end-wall is usually very thin, and the protoplasm on artificial contraction commonly sticks to it just as in a sieve-tube, though no perforation of the wall has been found. Associated with the leptoids are similar cells without swollen ends and with thicker cross walls. Besides the hydrom and leptom, and situated between them, there is a tissue which probably serves to conduct soluble carbohydrates, and whose cells are ordinarily full of starch. This may be called *amylom*. The stem in this family falls into two divisions, an underground portion bearing rhizoids and scales, the *rhizome*, and a *leafy aerial stem* forming its direct upward continuation. The leaf consists of a central midrib, several cells thick, and two wings, one cell thick. The midrib bears above a series of closely set, vertical, longitudinally-running plates of green assimilative cells over which the wings close in dry air so as to protect the assimilative and transpiring plates from excessive evaporation of water. The midrib has a strong band of stereom above and below. In its centre is a band-shaped bundle consisting of rows of leptom, hydrom, and amylom cells. This bundle is continued down into the cortex of the stem as a leaf trace, and passing very slowly through the sclerenchymatous external cortex and the parenchymatous, starchy internal cortex to join the central cylinder. The latter has a central strand consisting of files of large hydroids, separated from one another by very thin walls, each file being separated from its neighbour by stout, dark-brown walls. This is probably homologous with the hydroid cylinder in the stems of other mosses. It is surrounded by (1) a thin-walled, smaller-celled hydrom mantle; (2) a suberized amylom sheath; (3) a leptom mantle, interrupted here and there by starch cells. These three concentric tissue mantles are evidently formed by the conjoined bases of the leaf traces, each of which is composed of the same three tissues. As the aerial stem is traced down into the underground rhizome portion, these three mantles die out almost entirely—the central hydrom strand forming the bulk of the cylinder and its elements becoming mixed with thick-walled stereids; at the same time this central hydrom-stereom strand becomes three-lobed, with deep furrows between the lobes in which the few remaining leptoids run, separated from the central mass by a few starchy cells, the remains of the amylom sheath. At the periphery of the lobes are some comparatively thin-walled living cells mixed with a few thin-walled hydroids, the remains of the thin-walled hydrom mantle of the aerial stem. Outside this are three arcs of large cells showing characters typical of the endodermis in a vascular plant; these are interrupted by strands of narrow, elongated, thick-walled cells which send branches into the little brown scales borne by the rhizome. The surface layer of the rhizome bears rhizoids, and its whole structure strikingly resembles that of the typical root of a vascular plant. In *Atrichum undulatum* the central hydrom cylinder of the aerial stem is a loose tissue, its interstices being filled up with thin-walled, starchy parenchyma. In *Dawsonia superba*, the finest of all known mosses, the hydroids of the central cylinder of the aerial stem are mixed with thick-walled stereids forming a hydrom-stereom strand somewhat like that of the rhizome in other Polytrichaceæ.

The central hydrom strand in the seta of the sporogonium of most mosses has already been alluded to. Besides this there is usually a living conducting tissue sometimes differentiated as leptom forming a mantle round the hydrom, and bounded externally by a more or less well-differentiated endodermis, abutting on an irregularly cylindrical lacuna; the latter separates the central conducting cylinder from the cortex of the seta, which, like the cortex of the gametophyte stem, is usually differentiated into an outer thick-walled stereom and an inner starchy parenchyma. Frequently, also, a considerable differentiation of vegetative tissue occurs in the wall of the spore-capsule itself, and in some of the higher forms a special assimilating and transpiring organ situated just below the capsule at the top of the seta, with a richly lacunar chlorophyllous parenchyma and stomata like those of the wall of the capsule in the Anthocerotean liverworts. Thus the histological differentiation of the sporogonium of the higher mosses is one of considerable complexity; but there is here even less reason to suppose that these tissues have any homology (phylogenetic community of origin) with the similar ones met with in the higher plants.

The facts of histological structure in the Bryophytic series are all such as we should expect to be developed in response to the exigencies of increasing adaptation to terrestrial life on soil, and of increasing size of the plant-body. In the liverworts we find fixation of the thallus by water-absorbing rhizoids; in certain forms with a localized region of water-absorption the development of a primitive hydrom or water-conducting system; and in others with rather a massive type of thallus the differentiation of a special assimilative and transpiring system. In the more highly developed series, the mosses, this last division of labour takes the form of the differentiation of special assimilative organs, the leaves, commonly with a midrib containing elongated cells for the ready removal of the products of assimilation; and in the typical forms with a localized absorptive region, a well-developed hydrom in the axis of the plant, as well as similar hydroid strands in the leaf-midribs, are constantly met with. In higher forms the conducting strands of the leaves are continued downwards into the stem, and eventually come into connexion with the central hydroid cylinder, forming a complete cylindrical investment apparently distinct from the latter, and exhibiting a differentiation into hydrom, leptom, and amylom which almost completely parallels that found among the true vascular plants. Similar differentiation, differing in some details, takes place independently in the other generation, the sporogonium. The stereom of the moss is found mainly in the outer cortex and in the midrib of the leaf.

Vascular Plants.

The body of the sporophyte in the great majority of the vascular plants (Pteridophytes and Phanerogams) shows a considerable increase in complexity over that found in the Bryophytes. The principal new feature in the external conformation of the body is the acquirement of "true" *roots*, the nearest approach to which in the lower forms we saw in the "rhizome" of Polytrichaceæ. The primary root is a downward prolongation of the primary axis of the plant. From this, as well as from various parts of the shoot system, other roots may originate. The root differs from the shoot in the characters of its surface tissues, in the arrangement of its vascular system and in the mode of growth at the apex, all features which are in direct relation to its normally subterranean life and its fixative and absorptive functions. Within the limits of the sporophyte generation the Pteridophytes and Phanerogams also differ from the Bryophytes in possessing special assimilative and transpiring organs, the leaves, though these organs are also developed in the gametophyte of many liverworts and of all the mosses. The leaves, again, have special histological features adapted to the performance of their special functions.

Tissue-systems.

Alike in root, stem, and leaf, we can trace a three-fold division of tissue-systems, a division of which there are indications among the lower plants, and which is the expression of the fundamental conditions of the evolution of a bulky differentiated plant-body. From the primitive uniform mass of undifferentiated assimilating cells, there is, on the one hand, a specialization of a surface layer regulating the immediate relations of the plant with its surroundings. In the typically submerged algæ and in submerged plants of every affinity this is the absorptive and the main assimilative layer, and may also by the production of mucilage be of use in the protection of the body in various ways. In the terrestrial plants it differs in the subterranean and subaerial parts, being in the former pre-eminently absorptive, and in the latter protective—provision at the same time being made for the gaseous interchange of oxygen and carbon dioxide necessary for respiration and feeding. This surface layer in the typically subaerial "shoot" of the sporophyte in Pteridophytes and Phanerogams is known as the *epidermis*, though the name is restricted by some writers, on account of developmental differences, to the surface layer of the shoot of Angiosperms, and by others extended to the surface layer of the whole plant in both these groups. On the other hand, we have an internal differentiation of conducting tissue, the main features of which have already been fully described. The remaining tissue of the plant-body, a tissue that we must regard phylogenetically as the remnant of the undifferentiated tissue of the primitive thallus, but which often undergoes further differentiation of its own, the better to fulfil its characteristically vital functions for the whole plant, is known, from its peripheral position in relation to the primitively central conducting tissue, as the *cortex*. The remaining important function for which provision has to be made in any plant-body of considerable size, especially when raised into the air, is that of *support*. Special tissues may be developed for this purpose in the cortex, or in immediate connexion with the conducting system, according to the varying needs of the particular type of plant-body.

Epidermis.

In relation to its characteristic function of protection, the epidermis, which, as above defined, consists of a single layer of cells, has typically thickened and cuticularized outer walls. These serve not only to protect the plant against slight mechanical injury from without, but also and especially to prevent the evaporation of water from within, and to protect the internal tissues from the soaking in of rain, &c. At intervals it is interrupted by pores leading from the air outside to the intercellular space system below. These *stomata* are each surrounded by a pair of peculiarly modified epidermal cells called *guard-cells*, which open and close the pore according to the need for transpiration. The structure of the stomata of the sporophyte of vascular plants is fundamentally the same as that of the stomata on the sporogonium of the true mosses and of the liverwort *Anthoceros*, a striking fact that lends countenance to the theory which would derive the Pteridophytic sporophyte from the sporogonium of an *Anthoceros*-like ancestor. The stomata serve for all gaseous interchange between the plant and the surrounding air. The guard-cells contain chlorophyll, which is absent from typical epidermal cells, the latter acting as a tissue for water storage. Sometimes the epidermis is considerably more developed by tangential division of its cells, forming a many-layered water-tissue. The extremely various modifications of the epidermis, especially in connexion with the occurrence of *hairs* of the most various kinds, and the numberless differences in the distribution of the stomata, and their relation to the general surface of the epidermis, are concisely treated as to the leading facts in BOTANY (*Ency. Brit.* vol. iv. pp. 89-91), and in HISTOLOGY (vol. xii. p. 17). Mention may be made here of a class of epidermal organ, the *hydathode*, the wide distribution and variety of which have been revealed by recent research.

Hydathodes.

These are special organs usually situated on foliage leaves for the excretion of water in liquid form when transpiration is diminished so that the pressure in the water-channels of the plant has come to exceed a certain limit. They are widely distributed, but are particularly abundant in the tropics. In one type they may take the form of specially-modified single epidermal cells or multicellular hairs without any direct connexion with the vascular system. The cells concerned, like all secreting organs, have abundant protoplasm with larger nuclei, and sometimes, in addition, part of the cell-wall is modified as a filter. In a second type they are situated at the ends of tracheal strands and consist of groups of richly protoplasmic cells belonging to the epidermis (leaves of many ferns), or to the subjacent tissue (the commonest type in flowering plants); in this last case the cells in question are known as *epithema*. The epithema is penetrated by a network of fine intercellular spaces, which are normally filled with water and debouch on one or more intercellular cavities below the epidermis. Above each cavity is situated a so-called *water-stoma*, no doubt derived phylogenetically from an ordinary stoma, and enclosed by guard-cells which have nearly or entirely lost the power of movement. The pores of the water-stomata are the outlets of the hydathode. The epithema is frequently surrounded by a sheath of cuticularized cells; in other cases the epithema may be absent altogether, the tracheal strand debouching directly on the lacunæ of the mesophyll. This last type of hydathode is usually situated on the edge of the leaf. Some hydathodes are active *glands*, secreting the water they expel from the leaf. Many other types of glands also exist, either in connexion with the epidermis or not, such as nectaries, digestive glands, oil, resin and mucilage glands, &c.

The surface layer of the root, sometimes included under the term epidermis, is fundamentally different from the epidermis of the stem. In correspondence with its water-absorbing function it is not cuticularized, but remains usually thin-walled; the absorbing surface is increased by its cells being often produced into delicate tubes which curl round and adhere firmly to particles of soil, thus at once fixing the root firmly in the soil, and enabling the hair to absorb readily the thin films of water ordinarily surrounding the particles. The *root-hair* ends blindly and is simply an outgrowth from a surface cell, having no cross walls. It corresponds in function with the rhizoid of a bryophyte. At the apex of a root, covering and protecting the delicate tissue of the growing point, is a special *root-cap* consisting of a number of layers of tissue whose cells break down into mucilage towards the outer surface, thus facilitating the passage of the apex as it is pushed between the particles of soil.

Cortex.

The cortex, as has been said, is in its origin the remains of the primitive assimilating tissue of the plant, after differentiation of the surface layer and the conducting system. It consists primitively and mainly of typical living parenchyma; but its differentiation may be extremely varied, since in the complex body of the higher plants its functions are very various. In all green plants, where there is a special protective epidermis, the cortex of the shoot has to perform the primitive fundamental function of carbon assimilation. In the leafy shoot this is mainly localized in the cortical tissue of the leaves, known as *mesophyll*, which is essentially a parenchymatous tissue containing chloroplasts, and penetrated by a lacunar system so that the surfaces of the assimilating cells are brought into contact with air to as large an extent as possible in order to facilitate gaseous interchange between the assimilating cells and the atmosphere. At the same time the cells of the mesophyll are transpiring cells—*i.e.*, the evaporation of water from the leaf goes on from them into the intercellular spaces. The only pathways for the gases which thus pass between the cells of the mesophyll and the outside air are the stomata. A typical land plant has always to protect itself against over-transpiration, and for this reason the stomata are placed mainly or exclusively on the lower side of the leaf, where the water-vapour that escapes from them, being lighter than air, cannot rise away from the surface of the leaf, but remains in contact with it and thus tends to check further transpiration. The stomata are in direct communication with the richest lacunar system, which is found in the loosely arranged mesophyll (*spongy tissue*) on that side. This is the main transpiring tissue, and is protected from direct illumination and consequent too great evaporation. The main assimilating tissue, on the other hand, is under the upper epidermis, where it is well illuminated, and consists of oblong cells densely packed with chloroplasts and with their long axes perpendicular to the surface (*palisade tissue*). The intercellular spaces are here fewer and narrower. The whole lacunar system thus forms a kind of funnel, with its narrow end in the palisade and its wide end under the stomata, so that the double necessity for the limitation of transpiration and the illumination of the palisade cells lessens the amount of carbon dioxide which can reach the latter. Leaves whose blades are placed vertically possess palisade tissue and stomata on both sides (*isobilateral leaves*), since there is no difference in the illumination, while those which are cylindrical or of similar shape (*centric leaves*) have it all round. The leaves of shade plants have little or no differentiation of palisade. In fleshy leaves which have little or no chlorophyll, the central mesophyll is abundant and acts as water-storage tissue. The cortex of a young stem is usually green, and plays a more or less important part in the assimilative function. It also always possesses a well-developed lacunar system communicating with the external air through stomata (in the young stem) or *lenticels* (see below). This lacunar system not only enables the cells of the cortex itself to respire, but also forms channels through which air can pass to the deeper-lying tissues. The cortex of the older stem and of the root frequently acts as a reserve store-house for food, which generally takes the form of starch, and it also assists largely in providing the stereom of the plant. In the leaf-blade this often appears as a layer of thickened subepidermal cells, the *hypoderm*, often also as subepidermal bundles of sclerenchymatous fibres or of similar bundles extending right across the leaf from one epidermis to the other, and thus acting as struts. Isolated cells (*idioblasts*), thickened in various ways, are not uncommonly found supporting the tissues of the leaf. In the larger veins of the leaf, especially the midrib, in the petiole and in the young stem, an extremely frequent type of mechanical tissue is *collenchyma*. This consists of elongated cells with cellulose walls, which are locally thickened along the original corners of the cells, reducing the lumen to a cylinder, so that a number of vertical pillars of cellulose connected by comparatively thin walls form the framework of the tissue. This tissue remains living and is usually formed quite early just below the epidermis, where it provides the first peripheral support for a still growing stem or petiole. Sclerenchyma may be formed later in various positions in the cortex, according to local needs. Scattered single stereids or bundles of fibres are not uncommon in the cortex of the root.

Phloeoterma.

The innermost layer of the cortex, abutting on the central cylinder of the stem or on the bundles of the leaves, is called the *phloeoterma*, and is often differentiated. In the leaf-blade it takes the form of special parenchymatous sheaths to the bundles. The cells of these sheaths are often distinguished from the rest of the mesophyll by containing little or no chlorophyll. Occasionally, however, they are particularly rich in chloroplasts. These bundle sheaths are important in the conduction of carbohydrates away from the assimilating cells to other parts of the plant. Rarely in the leaf, fairly frequently in the stem (particularly in Pteridophytes), and universally in the root, the phloeoterma is developed as an *endodermis* (see below). In other cases, it does not differ histologically from the parenchyma of the rest of the cortex, though it is often distinguished by containing particularly abundant starch, in which case it is known as a *starch sheath*.

Vascular system.

Tissue elements.

One of the most striking characters common to the two highest groups of plants, the Pteridophytes and Phanerogams, is the possession of a double (hydrom-leptom) conducting system, such as we saw among the highest mosses, but with sharply characterized and peculiar features, almost certainly indicating common descent throughout both these groups. It is confined to the sporophyte, which forms the leafy-plant in these groups and is known as the *vascular system*. Associated with it are other tissues, consisting primitively of parenchyma, mainly starchy, and in the Phanerogams particularly, of special stereom. The whole tissue system is known as the *Stelar system*. It has no direct phylogenetic connexion with that of the mosses. The origin of the Pteridophyta (*q.v.*) is very obscure, but it may be regarded as certain that it is not to be sought among the mosses, which are an extremely specialized and peculiarly differentiated group. Furthermore, both the hydrom and leptom of Pteridophytes have marked peculiarities to which no parallel is to be found among the Bryophytes. Hence we must conclude that the conducting system of the Pteridophytes has had an entirely separate evolution. All the surviving forms, however, have a completely established double system with the specific characters alluded to, and since there is every reason to believe that the conditions of evolution of the primitive Pteridophyte must have been essentially similar to those of the Bryophytes, the various stages in the evolution of the conducting system of the latter are very useful to compare with the arrangements met with in the former. The hydroid of a Pteridophyte or of a Phanerogam is characteristically a dead, usually elongated, cell containing air and water, and either thin-walled with lignified spiral or annular thickenings, or with thick lignified walls, incompletely perforated by pits (usually bordered pits) of various shapes. When a number of such cells, called *tracheids*, placed end to end, have open communication with one another, the resulting cell-fusion is called a *vessel*. Vessels are very rare among Pteridophytes, though common among Phanerogams. The tracheids or vessels, indifferently called *tracheal elements*, together with the immediately associated cells (usually amylom in Pteridophytes) constitute the *xylem* of the plant. This is a morphological term given to the particular type of hydrom found in both Pteridophytes and Phanerogams, together with the parenchyma or stereom, or both, included within the boundaries of the hydrom tissue strand. The leptoid of a Pteridophyte is also an elongated cell, with a thin lining of protoplasm, but destitute of a nucleus, and always in communication with the next cell of the leptom strand by relatively large perforations (in Pteridophytes often not easily demonstrable), through which pass strings of protoplasm. These are often converted into a peculiar substance called *callose*, which is also frequently formed over the surface of the perforated, often extremely oblique, end-walls. The structure formed by a number of such cells placed end to end is called a *sieve-tube* (obviously comparable with a xylem-vessel), and the end-wall or area of end-wall occupied by a group of perforations, a *sieve-plate* (see CYTOLOGY). The sieve-tubes, with their accompanying parenchyma or stereom, constitute the tissue called *phloem*. This is likewise the term for a morphologically defined tissue system, *i.e.* the leptom found in Pteridophytes and Phanerogams with its associated cells, and is entirely parallel with the xylem. The sieve-tubes differ, however, from the tracheids in being immediately associated, apparently constantly, not with starchy parenchyma, but with parenchymatous cells containing particularly abundant proteid contents which seem to have a function intimately connected with the conducting function of the sieve-tubes, and which we may call *proteid-cells*.

Arrangement in strands: the central cylinder of monostele.

The xylem and phloem are nearly always found in close association in strands of various shapes in all the three main organs of the sporophyte—root, stem, and leaf—and form a connected tissue-system running through the whole body. In the primary axis of the plant among Pteridophytes and many Phanerogams, at any rate in its first formed part, the xylem and phloem are associated in the form of a cylinder, with xylem occupying the centre, and the phloem (in the upward growing part or primary stem) forming a mantle at the periphery (Fig. 3). In the downward growing part of the axis (primary root), however, the peripheral mantle of phloem is interrupted, the xylem coming to the surface of the cylinder along (usually) two or (sometimes) more vertical lines. Such an arrangement of vascular tissue is called *radial*, and is characteristic of all roots (Figs. 2 and 9). The cylinder is surrounded by a mantle of one or more layers of parenchymatous cells, the *pericycle*, and the xylem is separated from the phloem in the stem by a similar layer, the *mesocycle* (corresponding with the hydrom sheath in mosses). The pericycle and mesocycle together form the *conjunctive tissue* of the stele. In the root the mesocycle, like the phloem, is interrupted, and runs into the pericycle where the xylem touches the latter (Fig. 2). The whole cylinder is enclosed by the peculiarly differentiated innermost cell-layer of the cortex, known as the *endodermis*. This layer has its cells closely united and sealed to one another, so to speak, by the conversion of the radial and transverse walls (which separate each cell from the other cells of the layer), or a band running in the centre of these, into corky substance, so that the endodermal cells cannot be split apart to admit of the formation of intercellular spaces, and an air-tight sheath is formed round the cylinder. Such a vascular cylinder is called a *protostele*, and the axis containing it is said to be *protomonostelic*. In the stele of the root the strands of tracheids along the lines where the xylem touches the pericycle are spiral or annular, and are the xylem elements first formed when the cylinder is developing. Each strand of spiral or annular first-formed tracheids is called a *protoxylem* strand, as distinct from the *metaxylem* or rest of the xylem, which consists of thick-walled tracheids, the pits of which are usually scalariform. The stele is called *monarch, diarch, . . . polyarch* according as it contains one, two, . . . or many protoxylems. When the protoxylem strands are situated at the periphery of the stele, abutting on the pericycle, as in all roots, and many of the more primitive Pteridophyte stems, the stele is said to be *exarch*. When there is a single protoxylem strand in the centre of the stele, or when, as is more commonly the case, there are several protoxylem strands situated at the internal limit of the xylem, the centre of the stem being occupied by parenchyma, the stele is *endarch*. This is the case in the stems of most Phanerogams and a few Pteridophytes. When the protoxylems have an intermediate position the stele is *mesarch* (many Pteridophytes and some of the more primitive Phanerogams). In many cases external *protophloem*, usually consisting of narrow sieve-tubes often with swollen walls, can be distinguished from *metaphloem*. As the primitive stele of an exarch Pteridophyte is traced upwards from the primary root into the stem, the phloem and mesocycle become continuous round the xylem. At the same time the stele becomes more bulky, all its elements increasing in number. Very frequently the number of protoxylem strands increases by branching of the original ones that have come up from the root. Soon a bundle goes off to the first leaf. This consists of a protoxylem with a few metaxylem elements, a segment of mesocycle, phloem, pericycle, and usually an arc of endodermis, which closes round the bundle as it detaches itself from the stele. Thus such a leaf-bundle contains parts of all the tissues of the stele, and is hence called a *meristele*. It is primitively bilaterally symmetrical like the leaf it supplies, though it may acquire a radial symmetry of its own, while the stele of the stem is primitively radially symmetrical like the stem itself. As the stele is traced farther upwards it becomes bulkier, as do the successive leaf-bundles which leave it. In many Pteridophytes the solid protostele is maintained throughout the axis. In others a central parenchyma or *primitive pith*—a new region of the primitive stelar conjunctive—appears in the centre of the xylem. In many ferns *internal phloem* appears associated with this primitive pith; and at a higher level, after the stele has increased greatly in diameter, a large-celled *true pith* or *medulla*, resembling the cortex in its characters and usually quite distinct from conjunctive, appears in the centre. This is often separated from the conjunctive by an *internal endodermis*. Where internal phloem is present this is separated from the internal endodermis by an *endocycle* or "internal pericycle," as it is sometimes called, and from the xylem by an *internal mesocycle*—these two layers, together with the outer mesocycle and pericycle, constituting the conjunctive tissue of the now hollow cylindrical stele. (The conjunctive frequently forms a connected whole with bands of starchy *xylem-parenchyma*, which, when the xylem is bulky, usually appear among the tracheids, the phloem also often being penetrated by similar bands of *phloem-parenchyma*.) To this type of stele, whether with or without internal phloem, is given the name *siphonostele* to distinguish it from the solid *protostele* characteristic of the root, of the first-formed portion of the stem, and in the more primitive Pteridophytes of the whole of the axis. The siphonostele is, as it is found among many of the lower ferns, broken by the departure of a leaf-bundle, the outer and inner endodermis joining so that the stele becomes horseshoe-shaped and the cortex continuous with the pith (Fig. 4). Such a break is known as a *leaf-gap*. A little above the departure of the leaf bundle the stele again closes up, only to be again broken by the departure of the next meristele.

"Poly-stely." Where the leaves are crowded and the phyllotaxy is high, a given leaf-gap is not closed before the next ones appear, and the siphonostele thus becomes split up into a number of segments, sometimes band-shaped or semilunar, sometimes isodiametric in cross-section (Fig. 5). Each segment of the siphonostele frequently resembles a protostele, the segments of inner endodermis, pericycle, phloem, and mesocycle joining with the corresponding outer segments to form a concentric structure. For this reason a stem in which the vascular system has this type of structure is spoken of as *polystelic*, the term "stele" being transferred from the primary central cylinder of the axis and applied to the vascular strands just described. In this use the term loses, of course, its morphological value. Where the "steles" are few and band-shaped on cross-section, the structure is spoken of as "gamostelic"; where they are numerous, and run independently for considerable distances, it is "dialystelic." The splitting up of the vascular tube or siphonostele into separate strands does not depend wholly upon the occurrence of leaf-gaps. In the extremely dialystelic forms the leaf-gaps are very broad and long, and are filled by a network of slender strands, some of which run out to the leaf, while others form cross connexions between these and with the strands separating the gaps, which, though stouter than the leaf-gap steles, are reduced to comparatively narrow bands. In some cases the strands separating the gaps are themselves split up, further increasing the dialystely. Finally, the original dialystelic cylinder may be supplemented by additional internal or external strands or both, joining by frequent connexions the primary ones. The leaf-trace consists of a single strand only in some of the protostelic and more primitive siphonostelic forms, in the latter (where it is simply a detached segment of the siphonostele) having the shape of a crescent or horse-shoe in cross-section with the convexity outwards, and in the petiole downwards. In the more complex forms, as already indicated, the trace is itself split up into a number of strands which leave the base and sides of the leaf-gap independently. In the petiole these may increase in number by branching and sometimes form a complicated system resembling that of the stem, but usually reducible to the primitive bilateral horse-shoe type. The protostelic, siphonostelic, and "polystelic" conditions are mainly found among the Pteridophytes. There is good reason to suppose that the protostelic condition is primitive in evolution. Essentially the same type was found in the primitive conducting system of the gametophyte of the mosses. No doubt the siphonostele came next, sometimes perhaps in relation to the necessity for the formation of a hard peripheral supporting cylinder, but often owing to factors not yet understood, and by the crowding of the leaf-gaps and other factors the "polystelic" state was reached. Thus in tracing the stelar system of a "polystelic" fern, for instance, upwards from the primary root, the various stages which have led to the evolution of this type are passed through. In a few Pteridophytes and the great majority of the Phanerogams, the protostele of the primary root dilates either immediately upon entering the stem, or at a higher level, acquires a true medulla, and the vascular cylinder breaks into a number of separate *collateral bundles* (*i.e.*, with xylem towards the centre and phloem towards the periphery of the stem) which pass out of the cylinder to supply the leaves after having given off branches (*continuation bundles*) which continue their course in the cylinder of the stem. The lowest collateral bundles of the typical Phanerogamic stem are frequently directly continuous with the (often separate) strands forming the stele of the primary root, so that no siphonostelic condition of the type always found near the base of the stem of a higher Pteridophyte is passed through. But the collateral bundles of the stem stele are usually united laterally by conjunctive tissue, so that a hollow cylinder of stelar tissue is maintained, and the pith is isolated from the cortex except at the leaf-gaps. This modified siphonostele is very characteristic of the Phanerogamic stem. In the great majority of cases there is a fairly wide pericycle outside the phloem, and this is partially or wholly converted into sclerenchyma, usually of the prosenchymatous (fibrous) type. In this way an efficient peripheral supporting cylinder is secured, and it is no doubt largely owing to the need for this mechanical support that the modified siphonostele is maintained in the Phanerogamic stem. As it is, the single collateral bundle often asserts its individuality while still within the stele, the conjunctive being obviously arranged round them as centres—the sclerized pericycle, for instance, taking the form of a number of bands, arc-shaped in cross-section, capping the phloems of the bundles, and the cortex and medulla frequently intruding between two adjacent ones (Fig. 6). In some cases, indeed, the modified siphonostele breaks up altogether, the cortex and medulla becoming continuous between the bundles, each of which is surrounded by its own investment of tissue corresponding with conjunctive, but now called *perideem*, the isolated segment of the mesocycle being known as *mesodesm*. **Astely.** This is the condition of astely, entirely parallel with polystely except that the separate strands are usually all or mostly leaf-traces.

The difference between the concentric and the collateral structure of the strands, depending mainly on the presence or absence of internal phloem, and the difference between the rounded "stele" of the polystelic Pteridophyte with its tendency to radial organization, and the unipolar wedge-shaped "bundle" of the Dicotyledon usually with its cap or sheath of peridesmic stereom, depending on the different characters of the siphonostele from which the two types have been respectively evolved, though striking and characteristic enough, are of comparatively minor importance. The characteristic type of arrangement of vascular strands found in monocotyledonous stems depends on a similar extreme assertion of the individuality of the single leaf-trace bundle, combined with an often enormous increase in the number of bundles present at any given level. The result is a dilation of the stele till it occupies the whole or nearly the whole of the axis, the cortex being reduced to a narrow cylinder or disappearing altogether. The pericycle usually forms a sclerized band at or near the periphery of the stem, and the leaf-trace bundles are scattered in a definite though not superficially obvious order through a general parenchymatous ground tissue, each bundle being commonly capped or surrounded by its own sheath of stereom. In a few cases among the Phanerogams (e.g., *Auricula*) a polystelic condition originates secondarily in evolution by the association of supplementary internal inversely oriented bundles with detached arcs of the original stele. This is another method of increasing the vascular supply to the leaves when the needs of these exceed the capacity of the original dilated and broken central cylinder. In other cases polystely may originate in a completely astelic type by the association of bundles round common centres (*Nymphæa*).

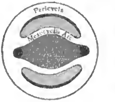


Fig. 2.

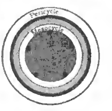


Fig. 3.

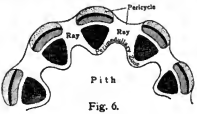
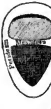


Fig. 6.

Fig. 7.



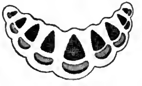


Fig. 8.

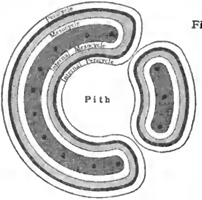


Fig. 4.

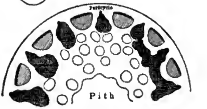


Fig. 9.

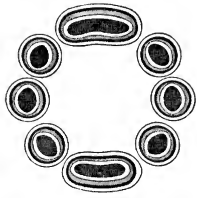


Fig. 5.

FIGS. 2-9.—DIAGRAMS OF THE MAIN TYPES OF ARRANGEMENT OF THE STELAR TISSUES IN PTERIDOPHYTES AND PHANEROGAMS (as seen in transverse section).

The xylem is cross-hatched, the phloem shaded diagonally, protoxylem and protophloem shaded darkly, parenchymatous conjunctive tissue left white, sclerenchyma dotted.

FIG. 2.—Diarch root-stele, with axial metaxylem plate joining the two protoxylems; the commonest type of primary root-stele.

FIG. 3.—Solid exarch protostele (represented as pentarch): base of most Pteridophyte stems, and throughout stem of more primitive forms.

FIG. 4.—Typical siphonostele (represented as mesarch) with internal phloem, broken by departure of a meristelic leaf-tree on the right. Characteristic of base of stem in most ferns, and of whole axis in many.

FIG. 5.—Simple dialystelic type; mesarch siphonostele represented as broken by two opposite leaf-gaps (right and left), each containing three meristelic leaf-traces, simulating protosteles and usually known as steles. Characteristic of the stems of most of the higher ferns.

FIG. 6.—Modified siphonostele with collateral endarch bundles separated laterally by conjunctive tissue. The regions of the latter outside the phloems are sclerized, as is usually the case. Characteristic of the dicotyledonous stem.

FIG. 7.—Separate collateral endarch bundle of an astelic form surrounded by its peridesm which may be partly or wholly sclerized. Xylem and phloem separated by mesodesm. Some dicotyledonous stems.

FIG. 8.—Meristelic arc of collateral bundles, united by conjunctive. Common in petioles of Dicotyledons.

FIG. 9.—Large polyarch root-siphonostele, showing radial arrangement of primary xylem and phloem in alternate strands, and also additional internal metaxylem, mostly in the form of large vessels. Found in many Monocotyledons. Most roots show some form intermediate between this and that represented in Fig. 2.

In the foregoing description of the evolution of the stelar

Aberrant forms.

system in vascular plants, account has been taken only of what seem the principal and more easily interpreted lines of descent. Among some of the Pteridophytes (*Selaginella*), a type of polystely is found which is not directly traceable to the breaking up of a primitive siphonostele by the crowding of leaf-gaps. Among the Cycadofilices also, a great group of extinct forms occupying the borderland between Ferns and Gymnosperms, side by side with monostelic types which furnish a most interesting sequence leading from the protostele so common among modern Pteridophytes to the modified siphonostele characteristic of modern Cycads, Conifers, and Dicotyledons, there are a number of siphonostelic and polystelic types (the *Medulloseæ* and allied forms) in which the breaking of the siphonostele does not depend upon the departure of leaf-traces. The structures presented are often of considerable complexity, and their origin and relationship with the more easily intelligible types are frequently obscure.

Stelar tissue of leaf, root, etc.

In the blade of a typical leaf of a vascular plant—essentially a thin plate of assimilating tissue—the vascular system takes the form of a number of separate, usually branching and anastomosing strands. These with their associated stereom form a kind of framework which is of great importance in supporting the mesophyll; but also, and chiefly, they provide a number of channels, penetrating every part of the leaf, along which water and dissolved salts are conveyed to, and elaborated food-substances from, the mesophyll cells. Each bundle is a branch of an original meristele that left the cylinder of the stem. It is always collateral (the phloem being turned downwards and the xylem upwards), even in Ferns, where the meristele or meristeles of the petiole ("petiolar steles") are concentric, and it has the ordinary mesodesm and peridesm of the collateral bundle. The latter is often sclerized, especially opposite the phloem, and to a less extent opposite the xylem, as in the stem. As a bundle is traced towards its blind termination in the mesophyll the peridesmic stereom first disappears, the sieve-tubes of the phloem are replaced by narrow elongated parenchyma cells, which soon die out, and the bundle ends with a strand of tracheids covered by the phloeoterm sheath.

The structure of the stele of the primary root as it is found in most Pteridophytes and many Phanerogams has been already described (Fig. 2). The radial structure is characteristic of all root-steles, which have in essential points a remarkably uniform structure throughout the vascular plants, a fact which is no doubt largely dependent on the very uniform conditions under which they live. The larger root-steles are usually polyarch, and seldom have the centre filled up with xylem, this being replaced by a large-celled pith so that the siphonostelic structure is acquired (Fig. 9). Sometimes, however, the centre of a bulky root stele has strands of metaxylem (to which may be added strands of metaphloem) scattered through it, the interstices being filled with conjunctive. The conjunctive of a root-stele possessing a pith is often sclerized between the pith and the pericycle. Sometimes all the parenchyma within the stele undergoes this change. In the roots of some palms the siphonostele breaks up into arcs, which may each acquire a "stelar" structure by the bending in and joining of the edges.

For "laticiferous tissue," see CYTOLOGY.

Development of primary tissue.

The body of a vascular plant is developed in the first place by repeated division of the fertilized egg and the growth of the products of division. The body thus formed is called the *embryo*, and this develops into the adult plant, not by continued growth of all its parts as in an animal, but by localization of the regions of cell-division and growth, such a localized region being called a *growing-point*. This localization takes place first at the two free ends of the primary axis, the descending part of which is the primary root, and the ascending the primary shoot. Later, the axis branches by the formation of new growing-points, and in this way the complex branch system of axes forming the body of the ordinary vascular plant is built up. In the flowering plants the embryo, after developing up to a certain point, stops growing and rests, enclosed within the *seed*. It is only on germination of the latter that the development of the embryo into the free plant is begun. In the Pteridophytes, on the other hand, development from the egg is continuous.

The triple division of tissues is laid down in most cases at a very early period of development—in the flowering plants usually before the resting stage is reached. In many Pteridophytes the first leaf is formed very early, and the first vascular strand is developed at its base, usually becoming continuous with the cylinder of the root; the strand of the second leaf is formed in a similar way and runs down to join that of the first, so that the stem stele is formed by the joined bases of the leaf-traces. In other cases, however, a continuous primitive stele is developed, extending from the primary stem to the primary root, the leaf-traces arising later. This is correlated with the comparatively late formation and small development of the first leaves. The evidence scarcely admits of a decision as to which of these methods is to be regarded as primitive in descent. In the seed-forming plants (*Phanerogams*) one or more primary leaves (*cotyledons*) are already formed in the resting embryo. In cases where the development of the embryo is advanced at the resting period, traces run from the cotyledons and determine the symmetry of the stele of the primitive axis, the upper part of which shows stem-structure, in some respects at least, and is called the hypocotyledonary stem or *hypocotyl*, while the lower part is the primary root (*radicle*). On germination of the seed the radicle first grows out, increasing in size as a whole, and soon adding to its tissues by cell division at its apical growing-point. The hypocotyl usually elongates by its cells increasing very greatly both in number and size, so that the cotyledons are raised into the air as the first foliage-leaves. Further growth in length of the stem is thenceforward confined to the apical growing point situated between the cotyledons. In other cases this growing-point becomes active at once, there being little or no elongation of the hypocotyl and the cotyledon or cotyledons remaining in the seed.

Growing-points.

The structure of the growing-points or apical meristems varies much in different cases. In most Pteridophytes there is a single large *apical cell* at the end of each stem and root axis. This usually has the form of a tetrahedron, with its base occupying the surface of the body of the axis and its apex pointing towards the interior. In the stem, segments are successively cut off from the sides of the tetrahedron, and by their subsequent division the body of the stem is produced. In the root exactly the same thing occurs, but segments are cut off also from the base of the tetrahedron, and by the division of these the root-cap is formed. In both stem and root early walls separate the cortex from the stele. The epidermis in the stem and the surface layer of the root soon becomes differentiated from the underlying tissue. In some Pteridophyte stems the apical cell is wedge-shaped, in others prismatic; in the latter case segments are cut off from the end of the prism turned towards the body of the stem. In other cases, again, a group of two or four prismatic cells takes the place of the apical cell. Segments are then cut off from the outer sides of these *initial cells*. In most of the Phanerogams the *apical* (or *primary*) *meristem*, instead of consisting of a single apical cell or a group of initials, is stratified—*i.e.*, there is more than one layer of initials. Throughout the Angiosperms the epidermis of the shoot originates from separate initials, which never divide tangentially, so that the young shoot is covered by a single layer of dividing cells, the *dermatogen*. Below this are the initials of the cortex and central cylinder. Whether these are always in layers which remain separate is not known, but it is certain that in many cases they cannot be distinguished. This, however, may be due to irregularity of division and displacement of the cells by irregular tensions destroying the obvious layered arrangement. In some cases there is a perfectly definite line of separation between the young cylinder (*plerome*) and young cortex (*periblem*), the latter having one or more layers of initials at the actual apex. This clear separation between periblem and plerome is mostly found in plants whose stem-apex forms a naked cone, the leaves being produced relatively late, so that the stele of the young stem is obvious above the youngest leaf-traces. Where the leaves are developed early, they often quite overshadow the actual apex of the stem, and the rapid formation of leaf tissue disturbs the obviousness of, and perhaps actually destroys, the stratified arrangement of the shoot initials. In this case also, the differentiation of leaf-bundles, which typically begins at the base of the leaf and extends upwards into the leaf and downwards into the stem, is the first phenomenon in the development of vascular tissue, and is seen at a higher level than the formation of a stele. The latter is produced (except in cases of complete astely where a cylinder is never formed) after a number of leaf-traces have appeared on different sides of the stem so as to form a circle as seen in transverse section, the spaces intervening between adjacent bundles becoming bridged by small-celled tissue closing the cylinder. In this tissue fresh bundles may become differentiated, and what remains of it becomes the rays of the fully-formed stele. Many cases exist which are intermediate between the two extreme types described. In these the stele becomes obvious in transverse section at about the same level as that at which the first leaf-traces are developed. Where a large-celled pith is developed this often becomes obvious very early, and in some cases it appears to have separate initials situated below those of the hollow vascular cylinder or modified siphonostele.

In some cases where there is apparently a well-marked plerome at the apex, this is really the young pith, the distinction between the stelar and cortical initials, if it exists, being, as is so often the case, impossible to make out. The young tissue of the stelar cylinder, in the case of the modified siphonostele characteristic of the dicotyledonous stem, differs from the adjoining pith and cortex in its narrow elongated cells, produced by the stopping of transverse and the increased frequency of longitudinal divisions. This is especially the case in the young vascular bundles themselves (*desmogen strands*). The protoxylem and protophloem are developed a few cells from the inner and outer margins of the desmogen strand, desmogenic tissue left over giving rise to the segments of endocycle and pericycle capping the bundle. Differentiation of the xylem progresses outwards, of the phloem inwards, but the two tissues never meet in the centre. Sometimes development stops altogether, and a layer of undifferentiated parenchyma, the *mesodesm*, is left between them; or it may continue indefinitely, the central cells keeping pace by their tangential division with the differentiation of tissue on each side. In this case the formation of the primary bundle passes straight over into the formation of secondary tissue by a cambium, and no line can be drawn between the two processes. The differentiation of the stelar stereom, which usually takes the forms of a sclerized pericycle, and may extend to the endocycle and parts of the rays, takes place in most cases later than the formation of the primary vascular strand. In the very frequent cases where the bundles have considerable individuality, the fibrous pericyclic cap very clearly has a common origin from the same strand of tissue as the vascular elements themselves.

The separation of layers in the apical meristem of the root is usually very much more obvious than in that of the stem. The outermost is the *calyptrogen*, which gives rise to the root cap, and in Dicotyledons to the piliferous layer as well. The *periblem*, one cell thick at the apex, produces the cortex, to which the piliferous layer belongs in Monocotyledons; and the *plerome*, which is nearly always sharply separated from the periblem, gives rise to the vascular cylinder. In a few cases the boundaries of the different layers are not traceable. The protoxylems and the phloem strands are developed alternately, just within the outer limit of the young cylinder. The differentiation of metaxylem follows according to the type of root-stele, and, finally, any stereom there may be is developed. Differentiation is very much more rapid—*i.e.*, the tissues are completely formed much nearer to the apex than is the case in the stem. This is owing to the elongating region (in which protoxylem and protophloem alone are differentiated) being very much shorter than in the stem. The root hairs grow out from the cells of the piliferous layer immediately behind the elongating region.

The branches of the stem arise by multiplication of the cells of the epidermis and cortex at a given spot, giving rise to a protuberance, at the end of which an apical meristem is established. The vascular system is connected in various ways with that of the parent axis by the differentiation of bundle-connexions across the cortex of the latter. This is known as *exogenous* branch-formation. In the root, on the other hand, the origin of branches is *endogenous*. The cells of the pericycle, usually opposite a protoxylem strand, divide tangentially and give rise to a new growing-point. The new root thus laid down burrows through the cortex of the mother-root and finally emerges into the soil. The connexions of its stele with that of the parent axis are made across the pericycle of the latter. Its cortex is never in connexion with the cortex of the parent, but with its pericycle. *Adventitious roots*, arising from the stems, usually take origin in the pericycle, but sometimes from other parts of the conjunctive.

Secondary tissues.

In most of the existing Pteridophytes, in the Monocotyledons, and in annual plants among the Dicotyledons, there is no further growth of much structural importance in the tissues after differentiation from the primary meristems. But in nearly all perennial Dicotyledons, in all dicotyledonous and gymnospermous trees and shrubs, and in fossil Pteridophytes belonging to all the great groups, certain layers of cells remain meristematic among the permanent tissues, or after passing through a resting stage reacquire meristematic properties, and give rise to *secondary tissues*. Such meristematic layers are called *secondary meristems*. There are two chief secondary meristems, the *cambium* and the *phellogen*. The formation of secondary tissues is characteristic of most woody plants, to whatever class they belong. Every great group or phylum of vascular plants, when it has become dominant in the vegetation of the world, has produced members with the tree habit arising by the formation of a thick woody trunk, in most cases by the activity of a cambium.

The *cambium* in the typical case, which is by far the most frequent, continues the primary differentiation of xylem and phloem in the desmogen strand (see above), or arises in the resting mesodesm or mesocycle and adds new (secondary) xylem and phloem to the primary tissues. New tangential walls arise in the cells which are the seat of cambial activity, and an *initial layer* of cells is established which cuts off *tissue mother-cells* on the inside and outside, alternately contributing to the xylem and the phloem. A tissue-mother-cell of the xylem may, in the most advanced types of Dicotyledons, give rise to—(1) a tracheid; (2) a segment of a vessel; (3) a xylem-fibre; or (4) a vertical file of xylem-parenchyma cells. In the last case the mother cell divides by a number of horizontal walls. A tissue-mother-cell of the phloem may give rise to—(1) a segment of a sieve-tube with its companion cell or cells; (2) a phloem fibre; (3) a single phloem-parenchyma (cambiform) cell, or a vertical file of short parenchyma cells. At certain points the cambium does not give rise to xylem and phloem elements, but cuts off cells on both sides which elongate radially and divide by horizontal walls. When a given initial cell of the cambium has once begun to produce cells of this sort it continues the process, so that a radial plate of parenchyma cells is formed stretching in one straight line through the xylem and phloem. Such a cell-plate is called a *medullary ray*. It is essentially a living tissue, and serves to place all the living cells of the secondary vascular tissues in communication. It conducts plastic substances inwards from the cortex, and its cells are frequently full of starch, which they store in winter. They are accompanied by intercellular channels serving for the conduction of oxygen to, and carbon dioxide from, the living cells in the interior of the wood, which would otherwise be cut off from the means of respiration. The xylem and phloem parenchyma consist of living cells, fundamentally similar in most respects to the medullary ray cells, which sometimes replace them altogether. The parenchyma is often arranged in tangential bands between the layers of sieve-tubes and tracheal elements. The xylem parenchyma is often found in strands associated with the tracheal elements. These strands are not isolated, but form a connected network through the wood. The xylem parenchyma cells are connected, as are the medullary ray cells, with the tracheal elements by one-sided bordered pits—*i.e.*, pits with a border on the tracheal element side, and simple on the parenchyma cell side. The fibres are frequently found in tangential bands between similar bands of tracheae or sieve-tubes. The fibrous bands are generally formed towards the end of the year's growth in thickness. The fibres belong to the same morphological category as the parenchyma, various transitions being found between them; thus there may be thin-walled cells of the shape of fibres, or ordinary fibres may be divided into a number of superposed cells. These intermediate cells, like the ordinary parenchyma, frequently store starch, and the fibres themselves, though usually dead, sometimes retain their protoplasm, and may also be used for starch accumulations. The vessels and tracheids are very various in size, shape, and structure in different plants. They are nearly always aggregated in strands, which, like those of the parenchyma, are not isolated, but connected with one another. In a few cases some of the tracheids have very thick walls and reduced cavities, functioning as mechanical rather than water-conducting elements. All transitions are found between such forms and typical tracheids. These *fibre-tracheids* are easily confused on superficial view with the true wood-fibres belonging to the parenchymatous system; but their pits are always bordered, though in the extreme type they are reduced to mere slits in the wall. The sieve-tubes of the secondary phloem usually have very oblique end-walls bearing a row of sieve-plates; plates also occur on the radial side-walls.

The tissue-elements just described are found only in the more complicated secondary vascular tissues of certain Dicotyledons. A considerable evolution in complexity can be traced in passing from the simplest forms of xylem and phloem found in the primary vascular tissues both among Pteridophytes and Phanerogams to these highly differentiated types. In the simplest condition we have merely tracheae and sieve-tubes, respectively associated with parenchyma, which in the former case is usually amylom, and in the latter consists of proteid cells. This type is found in nearly all Pteridophytes and, so far as is known, in Cycadofilices, both in primary and secondary tissue. The stereom is furnished either by cortical cells or by the tracheal elements, in a few cases by fibres which are probably homologous with sieve-tubes. Among Gymnosperms the secondary xylem is similarly simple, consisting of tracheids which act as stereom as well as hydrom, and a little amylom; while the phloem-parenchyma sometimes undergoes a differentiation, part being developed as amylom, part as proteid cells immediately associated with the sieve-tube. In other cases the proteid cells of the secondary phloem do not form part of the phloem-parenchyma, but occupy the top and bottom cell-rows of the medullary rays, the middle rows consisting of ordinary starchy cells. The top and bottom rows of the xylem rays are often developed as irregularly-thickened radially-elongated tracheids which serve for the radial conduction of water, and communicate with the ordinary tracheids of the secondary xylem by large bordered pits. The primary vascular tissues of Angiosperms are likewise nearly always simple, consisting merely of tracheæ and sieve-tubes often associated with amylom. A characteristic peculiarity, both in the primary and secondary tissue, is that the proteid cells of the phloem are here always sister-cells of the leptoids and are known as *companion-cells*. In the secondary tissues of Dicotyledons we may have, as already described, considerably more differentiation of the cells, all the varieties being referable, however, on the one hand to the tracheal or sieve-tube type, on the other to the parenchyma type. The main feature is the development of special vascular stereom and storage tissue. In some cases special secreting tissues, resin ducts, oil glands, laticiferous tissue, crystal sacs, &c., may be developed among the ordinary secondary vascular elements.

Annual rings.

The limit of each year's increment of secondary wood, in those plants whose yearly activity is interrupted by a regular winter or dry season, is marked by a more or less distinct line, which is produced by the sharp contrast between the wood formed in the late summer of one year (characterized by the sparseness or small diameter of the tracheal elements, or by the preponderance of fibres, or by a combination of these characters, giving a denseness to the wood) and the loose spring wood of the next year, with its absence of fibres, or its numerous large tracheæ. The abundance of water-conducting channels is in relation to the need for a large and rapid supply of water to the unfolding leaves in the spring and early summer. In Gymnosperms, where vessels and fibres are absent, the late summer wood is composed of radially narrow thick-walled tracheids, the wood of the succeeding spring being wide-celled and thin-walled, so that the limit of the year's growth is very well marked. The older wood of a large tree forming a cylinder in the centre of the trunk frequently undergoes marked changes in character. The living elements die, and the walls of all the cells often become hardened, owing to the deposit in them of special substances. Wood thus altered is known as heart-wood, or *duramen*, as distinguished from the young sap-wood, or *alburnum*, which, forming a cylinder next the cambium, remains alive and carries on the active functions of the xylem, particularly the conduction of water. The heart-wood ceases to be of any use to the tree except as a support, but owing to its dryness and hardness it alone is of much use for industrial purposes. The great hardness of teak is due to the silica deposited in the heart-wood, and the special colouring matters of various woods, such as yellow wood, ebony, &c., are confined to the heart-wood. In some cases the heart-wood, instead of becoming specially hard, remains soft and easily rots, so that the trunk of the tree frequently becomes hollow, as is commonly the case in the willow. Heart-wood is first formed at very different epochs in the life of a tree, according to the species—*e.g.*, after fifteen to twenty years in the oak, forty years in the ash, etc.

In many annual plants no cambium is formed at all, and the same is true of most perennial Pteridophytes and Monocotyledons.

Cambium in stems.

When the vascular tissue of such plants is arranged in separate bundles these are said to be *closed*. The bundles of plants which form cambium are, on the contrary, called *open*. In stems with open bundles the formation of cambium and secondary tissue may be confined to these, when it is said to be entirely *fascicular*. In that case either very little secondary tissue is formed, as in the gourds, some Ranunculaceæ, &c., or a considerable amount may be produced (clematis, barberry, ivy). In the latter event the cells of the primary rays are either merely stretched radially, or they divide to keep pace with the growth of the bundles. If this division occurs by means of a localized secondary meristem connecting the cambial layers of adjacent bundles, an *interfascicular* is formed in addition to the fascicular cambium. The interfascicular cambium may form nothing but parenchymatous tissue, producing merely continuations of the primary rays. Such rays are usually broader and more conspicuous than the secondary rays formed within the wedges of wood opposite the primary bundles, and are distinguished as *principal rays* from these narrower *subordinate* or *fascicular rays*. This is the typical case in most trees where the primary bundles are close together. Where the primary bundles are farther apart, so that the primary rays are wider, the interfascicular cambium may form several fairly broad (principal) secondary rays in continuation of certain radial bands of the primary ray, and between these, wedges of secondary xylem and phloem: or, finally, secondary xylem and phloem may be formed by the whole circumference of the cambium, fascicular and interfascicular alike, interrupted only by narrow secondary rays, which have no relation to the primary ones.

In a good many cases, sometimes in isolated genera or species, sometimes characteristic of whole families, so-called anomalous cambial layers are formed in the stem, either as an extension of, or in addition to, the original cambial cylinder. They are frequently associated with irregularities in the activity of the original cambium. Irregularity of cambium occurs in various families of woody dicotyledonous plants, mostly among the woody climbers, known as *lianes*, characteristic of tropical and subtropical forests. In the simplest cases the cambium produces xylem more freely along certain tracts of the circumference than along others, so that the stem loses its original cylindrical form and becomes elliptical or lobed in section. In others the secondary phloem is produced more abundantly in those places where the xylem is deficient, so that the stem remains cylindrical in section, the phloem occupying the bays left in the xylem mass. Sometimes in such cases the cambium ceases to be active round these bays and joins across the outside of the bay, where it resumes its normal activity, thus isolating a phloem lake, or, as it is usually called, a *phloem island*, in the midst of the xylem. The significance of these phenomena, which present many minor modifications in different cases, is not fully understood; but one purpose of the formation of phloem promontories and islands seems to be the protection of the sieve-tubes from crushing by the often considerable peripheral pressure that is exercised on the stems of these lianes. Sometimes the original cambial ring is broken into several arcs, each of which is completed into an independent circle, so that several independent secondary vascular cylinders are formed. The formation of additional cambial cylinders or bands occurs in the most various families of Dicotyledons and in some Gymnosperms. They may arise in the pericycle or endocycle of the stele, in the cortex of the stem, or in the parenchyma of the secondary xylem or phloem. The activity of the new cambium is often associated with the stoppage of the original one. Sometimes the activity of the successive cambiums simply results in the formation of concentric rings or arcs of secondary xylem and phloem. In other cases a most intricate arrangement of secondary tissue masses is produced, quite impossible to interpret unless all stages of their development have been followed. Sometimes in lianes the whole stem breaks up into separate woody strands, often twisted like the strands of a rope, and running into one another at intervals. An ordinary cambium is scarcely ever found in the Monocotyledons, but in certain woody forms a secondary meristem is formed outside the primary bundles, and gives rise externally to a little secondary cortex, and internally to a secondary parenchyma in which are developed numerous zones of additional bundles, usually of concentric structure, with phloem surrounded by xylem.

Cambium in roots.

The cambium in the root, which is found generally in those plants which possess a cambium in the stem, always begins in the conjunctive tissue internal to the primary phloems, and forms new (secondary) phloem in contact with the primary, and secondary xylem internally. In roots which thicken but slightly, whose cambium usually appears late, it is confined to these regions. If the development of secondary tissues is to proceed further, arcs of cambium are formed in the pericycle external to the primary xylems, and the two sets of cambial arcs join, forming a continuous, wavy line on transverse section, with bays opposite the primary phloems and promontories opposite the primary xylems. Owing to the resistance offered by the hard first-formed secondary xylem, the bays are pushed outwards as growth proceeds, and the wavy line becomes a circle. Opposite the primary xylems, the cambium either (*a*) forms parenchyma on both sides, making a broad, secondary (principal) ray, which interrupts the vascular ring and is divided at its inner extremity by the islet of primary xylem; or (*b*) forms secondary xylem and phloem in the ordinary way, completing the vascular ring. In either case, narrow, secondary rays are formed at intervals, just as in the stem. Thus the structure of an old thickened root approximates to that of an old thickened stem, and so far as the vascular tissue is concerned can often only be distinguished from the latter by the position and orientation of the primary xylems. The cambium of the primary root, together with the tissues which it forms, is always directly continuous with that of the primary stem, just in the same way as the tissues of the primary stele. The so-called anomalous cambiums in roots follow the same lines as those of the stem.

Phellogen and periderm.

In nearly all plants which produce secondary vascular tissues by means of a cambium there is another layer of secondary meristem arising externally to, but in quite the same fashion as, the cambium, and producing like the latter an external and an internal secondary tissue. This is the *phellogen*, and the whole of the tissue it gives rise to is known as *periderm*. The phellogen derives its name from the fact that its external product is the characteristic tissue known as *cork*. This consists typically of closely-fitting layers of cells with completely suberized walls, intended to replace the epidermis as the external protective layer of the plant when the latter, incapable as it is of further growth after its original formation, is broken and cast off by the increase in thickness of the stem through the activity of the cambium. Cork is also formed similarly in the root after the latter has passed through its primary stage as an absorptive organ, and has its structure assimilated to that of the stem. The internal tissue formed by the phellogen is known as *phelloderm*, and consists usually of ordinary parenchyma. The phellogen may arise, in the first place, in any tissue of the axis external to the actual vascular tissues—*i.e.*, in the epidermis itself (rarely), in any layer of the cortex, or in the pericycle. Its most usual seat of origin in the stem is the external layer of the cortex immediately below the epidermis; in the root, the pericycle. All the tissues external to the cork are cast off by the plant. The extent of development of the phelloderm is dependent upon whether the phellogen has a superficial or a deep-seated origin. In the former case the formation of phelloderm is trivial in amount; in the latter, considerable, since this tissue has to replace the cast-off cortex, as a metabolic and particularly a storage tissue. Provision is made for gaseous interchange between the internal tissues and the external air after the formation of cork, by the development of *lenticels*. These are special organs which interrupt the continuity of the impermeable layer of ordinary cork-cells. A lenticel is formed by the phellogen at a given spot dividing very actively and giving rise to a loose tissue of rounded cells which soon lose their contents, and between which air can pass to the tissues below. A lenticel appears to the naked eye as a rounded or elongated scar, often forming a distinct prominence on the surface of the organ. The lenticels of the stem are usually formed beneath stomata, whose function they take up after the stomata have been ruptured and cast off with the rest of the epidermis. Both cork and phelloderm may be differentiated in various ways. The former often has its cells lignified, and may consist of alternate layers of hard and soft cells. The latter may develop stereom, and may also be the seat of origin of new formations of various kinds—*e.g.*, supplementary vascular bundles, anomalous cambial zones, etc. It is often enormously developed and forms a very important tissue in roots. In the stem of a tree the original phellogen is replaced by successive new phellogenic layers of deeper and deeper origin, each forming its own layer of cork. Eventually the new phellogens reach the level of the secondary phloem, and are formed in the parenchyma of the latter, keeping pace in their inward march with the formation of fresh secondary phloem by the cambium. The complex system of dead and dying tissues cut off by these successive periderms, together with the latter themselves—in fact, everything outside the innermost phellogen, constitutes what is often known botanically as the *bark* of the tree. *Rhytidome* is, however, a preferable term, as the word bark has long been established in popular usage to mean all the tissue that can easily be peeled off—*i.e.*, everything down to the wood of the tree. The rough surface of the bark of many trees is due to the successive phellogens not arising in regular concentric zones, but forming in arcs which join with the earlier-formed arcs, and thus causing the bark to come off in flakes or thick chunks. A layer of cork is regularly formed in most Phanerogams across the base of the petiole before leaf fall, so as to cover the wound caused by the separation of the leaf from the stem. Special "wound-cork" is also often formed round accidental injuries so as to prevent the rotting of the tissues by the soaking in of rain and the entrance of fungal spores and bacteria. A peculiar modification of periderm is formed by the phellogen in the submerged organs (roots or stems) of many aquatic or marsh-loving plants. This may take various forms and may cover the whole of the organ or be localized in special regions; but its cells are always living and are separated by very large intercellular spaces. This tissue is called *aerenchym*, and no doubt its function is to facilitate the respiration of the organs on which it is formed and to which the access of oxygen is difficult. In other cases, a similar formation of spongy but dead periderm cells may occur for the same purpose in special patches, called *pneumatodes*, on the roots of certain trees living in marshy places, which rise above the soil in order to obtain air.

History and Bibliography.—The study of plant anatomy was begun in the middle of the seventeenth century as a direct result of the construction of microscopes, with which a clear view of the structure of plant tissues could be obtained. The Englishman Grew and the Italian Malpighi almost simultaneously published illustrated works on the subject, in which they described, for the most part very accurately, what they saw with the new instruments. The subject was practically dormant for nearly a century and a half, largely owing to the dominance of classificatory botany under the influence of Linneus. It was revived by several German workers, prominent among whom were Treviranus and Link, and later Moldenhawer, as well as by the Frenchman Mirbel, at the beginning of the nineteenth century. The new work largely centred round a discussion of the nature and origin of *vessels*, conspicuous features in plant tissues which acquired an importance quite out of proportion to their real place in the construction of the vascular plant. The whole of the writings of this time are dominated by a preoccupation with the functions of the different tissues, in itself an excellent standpoint for investigation, but frequently leading in the case of these early investigators to one-sided and distorted views of the facts of structure. The pioneer of modern plant anatomy was Hugo von Mohl (fl. 1840), who carefully investigated and described the facts of anatomical structure without attempting to fit them into preconceived views of their meaning. He produced a solid body of accurately described facts which has formed the secure groundwork of subsequent advance. From Mohl down to the eighth decade of the century the study of anatomy was entirely in the hands of a group of German investigators, prominent in which are the names of several of the most eminent founders of modern scientific botany—such, for instance, as Nägeli, Sanio, and De Bary. To the first we owe the secure foundation of our knowledge of the structure and course of the vascular strands of the higher plants ("Ueber den Bau und die Anordnung der Gefassbündel bei den Stamm und Wurzel der Phanerogamen," *Beiträge zur Wissenschaftlichen Botanik*, Heft i., Leipzig, 1859); to the second the establishment of the sound morphological doctrine of the central cylinder of the axis as the starting-point for the consideration of the general arrangement of the tissues, and the first clear distinction between primary and secondary tissues (*Botanische Zeitung*, 1861 and 1863); to the last the putting together of the facts of plant anatomy known up to the middle of the eighth decade of the century in that colossal encyclopædia of plant anatomy, the *Vergleichende Anatomie der Vegetationsorgane bei den Phanerogamen und Farnen*, Stuttgart, 1876. (English translation: *Comparative Anatomy of the Vegetative Organs of the Phanerogams and Ferns*, Oxford, 1882.) In 1870-71, Van Tieghem published his great work, "Sur la Racine," *Ann. Sci. Nat. Bot.* Paris. This was not only in itself an important contribution to plant anatomy, but served as the starting-point of a series of researches by Van Tieghem and his pupils, which have considerably advanced our knowledge of the details of histology, and also culminated in the foundation of the doctrine of the stele (Van Tieghem and Douliot, "Sur la Polystélie," *Ann. Sci. Nat. Bot.* 1887; Van Tieghem, *Traité de Botanique*, 2nd ed. Paris, 1889-91), which has had a most important effect on the development in recent years of morphological anatomy. In the progress of the last quarter of a century, since the publication of De Bary's great work, four main lines of advance can be distinguished. First, the knowledge of the details of histology has of course advanced greatly in every direction through the ceaseless activity of very numerous, but mainly German, workers, though no fundamentally new types of tissue have been discovered. Secondly, the histology of fossil plants, particularly woody plants of the carboniferous period, has been placed on a sound basis, assimilated with general histological doctrine, and has considerably enlarged our conceptions of plant anatomy as a whole, though again without revealing any entirely new types of structure. This branch of the subject, founded by Corda, Göppert, Stenzel and others in Germany, was enormously advanced by Williamson's work on the Coal Measures plants, recorded in the magnificent series of memoirs, "Researches on the Organization of Fossil Plants of the Coal Measures," *Phil. Trans. Roy. Soc.* i.-xix., 1871-93. The work of Solms Laubach in Germany, Renault and Bertrand in France, and in quite recent years, of Zeiller in France, and Scott and Seward in England, has advanced our knowledge of the anatomy of fossil plants in an important degree. While convincing us that the plants of past ages in the earth's history were exposed to very similar conditions of life, and made very much the same adaptive responses as their modern representatives, one of the main results of this line of work has been to reveal important data enabling us to fill various gaps in our morphological knowledge and to obtain a more complete picture of the evolution of tissues in the vascular plants. One of the most striking incidents in the progress has been the recognition within the last few years of the existence of an extinct group of plants lying on the borderland between Ferns and Gymnosperms, and known as the Cycadofilices, a group in which, curiously enough, the reproductive organs have not yet been discovered, but the anatomy of whose members affords sufficient evidence of their true affinities. Thirdly, we have to record very considerable progress in our knowledge of that distinctively morphological anatomy to which reference was made in the introduction to this article. The Russian plant-anatomist, Russow, may be said to have founded the consideration of plant tissues from the point of view of descent (*Vergleichende Untersuchungen über die Leitbündel-kryptogamen*. St Petersburg, 1872; and *Betrachtungen über Leitbündel und Grundgewebe*. Dorpat, 1875). He has been ably followed by Strasburger (*Ueber den Bau und die Verrichtungen der Leitungsbahnen in den Pflanzen*, Jena, 1891), Haberlandt and others. The explicit adoption of this point of view has had the effect of clearing up and rendering definite the older morphological doctrines, which for the most part had no fixed criterion by which they could be tested. This has been conspicuously the case with regard to Van Tieghem's famous doctrine of the *stele*, which has quite lately been severely criticized from this point of view in England and America, where morphological anatomy is at the present time being actively pursued by Scott, Gwynne-Vaughan, Jeffrey, and others. Fourthly, we have to record the foundation of the modern study of physiological anatomy by Schwendener (*Das mechanische Princip im Bau der Monocotylen*, 1874, and other works), followed by numerous pupils and others, among whom Haberlandt (*Physiologische Pflanzen-Anatomie*, Leipzig, 1st ed. 1884, 2nd ed. 1896, and other works) is pre-eminent. The pursuit of this study has not only thrown valuable light on the economy of the plant as a whole, but forms an indispensable condition of the advance of morphological anatomy.

(A. G. T.)

Anazarba, *Anazarbus*, or *Cæsarea ad Anazarbum*, the metropolis of Cilicia Secunda, situated N.E. of Adana in the rich Cilician plain at the foot of an isolated ridge of rock upon which stood its acropolis. In the 12th century it was for a time the capital of Lesser Armenia, and its ruins are striking and interesting.

Ancachs, a coast department of central Peru, with an area of 16,562 square miles, and a population officially estimated at 428,703. It embraces seven provinces, Santa, with the town of Santa (population, 3000); Pallasca, with the town of Samanco (2000); Pomabamba, with the town of Huarmey (1500); Huaraz, with the town of Huaraz (8000); Huaylas, with the town of Huaylas (6000); Huari, and Cajartambo. In the sierra are the important towns of Caraz (6000) and Carhuaz (5000).

Anchor, the instrument which, secured to a ship by a cable, enables her to ride in safety, and therefore forms one of the most important articles in the vessel's equipment. Until the beginning of the 19th century anchors were of imperfect manufacture, the means of effecting good and efficient welding being absent and the iron poor, whilst the arms, being straight, generally parted at the crown, when weighing from good holding ground. Mr Pering in the early part of the century introduced curved arms; and twenty-five years later, the Admiralty anchor, under the direction of the Board, was supplied to H.M. ships, followed by Lieutenant (afterwards Captain) Rodger's anchor, with well-formed arms, shank, and crown, the points or pees to the palm being blunt. This anchor had an excellent reputation amongst nautical men of that period. The Committee on Anchors, appointed by the Admiralty in 1852, placed at the head of the list Trotman and Rodger's anchors. In the former a great departure from previous anchors was made, the arms in one piece pivoted on a bolt through a fork-shaped shank; later came the self-canting and close-stowing Martin anchor, which, passing through successive improvements in design and manufacture, is largely used in the Royal Navy and mercantile marine.

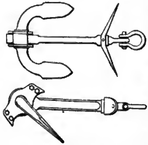


Fig. 1.—Improved Martin Anchor.

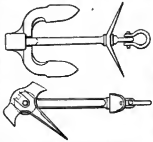


Fig. 2.—Improved Martin-Adelphi Anchor.

The improved Martin anchor (Fig. 1) is made of forged iron; a projection in the centre of the arms works in a recess at the heel of the shank; the arms when in position are secured by side plates close to the heel of the shank; the vacancies outside the shank are filled by blocks bolted through on each side and are flush with the side plates, the latter keeping the flukes in position. The introduction of cast-steel in 1894 led to the improved Martin-Adelphi pattern (Fig. 2). The crown and arms are cast in one, and, with the stock, are made of cast-steel, the shank remaining of forged iron; a projection in the crown works in a recess (lower Fig. 2), secured in its place by a forged steel pin passing through crown and heel of shank; a nut with washer is fitted to the pin. Stockless anchors are extensively used in the British mercantile marine and in some foreign navies; their advantages are—handiness, absence of davits, and a clear forecastle for right ahead gun fire or for working ship. Should experience prove that a stockless anchor possesses the same holding power as a stocked one, it will supersede the latter. Hall's stockless anchor is shown in Figs. 3 and 3*a*, and Riley's in Fig. 4. The latter is made in three pieces

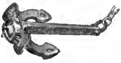


Fig. 3.—Hall's Stockless Anchor.

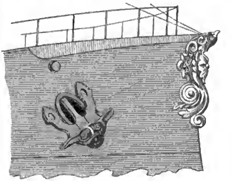


Fig. 3a.—Hall's Stockless Anchor stowed.

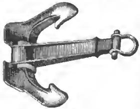


Fig. 4.—Riley's Stockless Anchor.

—a shank, a fast fluke, and a loose one; the fast fluke has a square end cast on the neck, and is passed through the shank, and the loose one is riveted and pinned on to the square end; a deep vertical rib or flange is cast at the back of the flukes, and, together with the stops on the shank, serves to tilt the flukes at an angle for taking the ground. To stow an anchor in a modern man-of-war it is hove up close to the forefoot, and the inner end of a ground chain which is stopped and secured to the cable will be inside the hawse pipe, whilst its outer end is secured to a balancing (gravity) band, consisting of an iron strap and shackle on the shank of the anchor. Before weighing, the outer end of the catting chain is rove through an iron leading block on the cat davit, and the iron swivel block (Fig. 5, AA) at the cathead, and taken in through the hawse pipe; when the inner end of the ground chain is sufficiently inboard, the ground and catting chains are joined and the latter brought to the capstan, and the anchor hoisted up horizontally and placed by the cat davit, which pivots at its base (Fig. 5, B) on the bill-board, and secured by chains; an end of each chain passing over a rod with lever for letting go; additional chains are employed for securing at sea. For right ahead fire and for sea, the cat davit hinged (Fig. 5, B) is stowed in position indicated by the dotted line (Fig. 5, C). Ground and catting chains are being superseded in some ships by a wire pendant and cat hook, the anchor being hove close up to the hawse pipe. To avoid cutting away a portion of the forecastle, anchors are stowed à Cock Bill (Fig. 6), the crowns resting on iron shoes secured to the ship's side, the flukes being fore and aft; the cat-heads are short. To let go, the securing chains are cleared away, except the shank painters, which are freed by the rod A, actuated by the lever B; additional securing chains and bolts (EE and EE) are used for sea. A difficulty is experienced in stowing the anchor when pitching or rolling heavily. Fig. 7 illustrates an anchor with cat davit or anchor crane used in the P. & O. S. N. Company steamers ("India class 8000 tons"); for sea the anchor is stowed inboard by the anchor crane. The equipment of anchors for this class is: bowers—two Rodger's box stocked 58 cwt. and two Hall's stockless 66 cwt.; stream—one Hall's 28 cwt.; kedges—one Martin, 13½ cwt., two Martin, 8 cwt., and one Martin, 6 cwt. Stern, stream, and kedge anchors are usually stowed by special davits. A portable anchor suitable for small yachts is the invention of Mr Louis Moore; the shank passes through the crown of the anchor like the handle of a pickaxe, and the stock over the head of the shank; at the end of the stock are loose pawls; there are no keys or bolts, and the only fastening is for the cable; the anchor takes to pieces readily and stows snugly. In 1890 Colonel Bucknell also invented a portable anchor for small yachts. Iron buoy sinkers (Fig. 8) used by the Trinity House Corporation are from 8 to 40 cwt.; the specified weight is cast on them in large raised figures; the cast and wrought iron used is of special quality; samples are previously submitted to the engineer-in-chief.

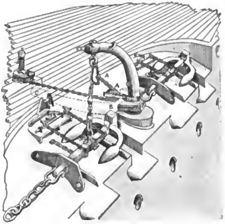


FIG. 5.—Anchor stowed

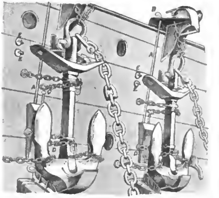


FIG. 6.—Anchor stowed à Cock Bill.

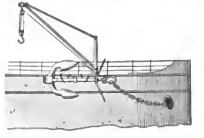


FIG. 7. Anchor Crane.

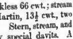


FIG. 8.—Iron Buoy Sinker.

The tests for anchors supplied to H.M. ships are in tons proportionate to their weights in cwts.; new anchors are supplied by contractors, but repairs afterwards are made in H.M. dockyards, and by stamping a record is kept on the anchor of its repairs. In "Anchors and Cables Act, 1899," a list is given of authorized testing establishments, with their distinctive marks and charges, and testing houses for foreign-owned vessels are in table 22 of Lloyd's *Register of British and Foreign Shipping*. Cast-steel anchors, in addition to the statutory tests, are subjected to percussive, hammering, and bending tests, and are stamped "annealed steel." (J. W. D.)

Anchovy (*Engraulis encrasicholus*), a fish of the herring family, easily distinguished by its deeply cleft mouth, the angle of the gape being behind the eyes. The pointed snout extends beyond the lower jaw. The fish resembles a sprat in having a forked tail and a single dorsal fin, but the body is round and slender. The maximum length is 8½ inches. Anchovies are abundant in the Mediterranean, and are regularly caught on the coasts of Sicily, Italy, France, and Spain. The range of the species also extends along the Atlantic coast of Europe to the south of Norway. In winter it is common off Devon and Cornwall, but has not hitherto been caught in such numbers as to be of commercial importance. Off the coast of Holland in summer it is more plentiful, entering the Zuyder Zee in such numbers as to give rise to a regular and valuable fishery. It is also taken in the estuary of the Scheldt. There is reason to believe that the anchovies found at the western end of the English Channel in November and December are those which annually migrate from the Zuyder Zee and Scheldt in autumn, returning thither in the following spring; they must be held to form an isolated stock, for none come up from the south in summer to occupy the English Channel, though the species is resident on the coast of Portugal. The explanation appears to be that the shallow and land-locked waters of the Zuyder Zee, as well as the sea on the Dutch coast, become raised to a higher temperature in summer than any part of the sea about the British coasts, and that therefore anchovies are able to spawn and maintain their numbers in these waters. Their reproduction and development were first described by a Dutch naturalist from observations made on the shores of the Zuyder Zee. Spawning takes place in June and July, and the eggs, like those of the majority of marine fishes, are buoyant and transparent, but they are peculiar in having an elongated, sausage-like shape, instead of being globular. They resemble those of the sprat and pilchard in having a segmented yolk, and there is no oil globule. The larva is hatched two or three days after the fertilization of the egg, and is very minute and transparent; its further development has not been traced. In August young specimens 1½ to 3½ inches in length have been taken in the Zuyder Zee, and these must be held to have been derived from the spawning of the previous summer. There is no evidence to decide the question whether all the young anchovies as well as the adults leave the Zuyder Zee in autumn, but, considering the winter temperature there, it is probable that they do. The eggs have also been obtained from the Bay of Naples, and near Marseilles, also off the coast of Holland, and once at least off the coast of Lancashire. The occurrence of anchovies in the English Channel has been carefully studied at the laboratory of the Marine Biological Association at Plymouth. They were most abundant in 1889 and 1890. In the former year considerable numbers were taken off Dover in drift nets of small mesh, used for the capture of sprats. In the following December large numbers were taken together with sprats at Torquay. In November 1890 a thousand of the fish were obtained in two days from the pilchard boats fishing near Plymouth; these were caught near the Eddystone. When taken in British waters anchovies are either thrown away, or sent to the market fresh with the sprats. If salted in the proper way, they would doubtless be in all respects equal to Dutch anchovies, if not to those imported from Italy. The supply, however, is small and inconstant, and for this reason English fish-curers have not learnt the proper way of preparing them. The so-called "Norwegian anchovies" imported into England in little wooden kegs are nothing but sprats pickled in brine with bay-leaves and whole pepper. (J. T. C.)

Ancona, one of the sixty-nine provinces of the kingdom of Italy, bounded on the N. by the Province of Pesaro-Urbino; on the W. by Pesaro-Urbino and Umbria; on the S. by the Province of Macerata; and on the E. by the Adriatic Sea. It has an area of 788 square miles and a population of (1901) 302,460. Owing largely to the *mezzadria* or *métayer* system, under which products are equally divided between the owners and the cultivators of the land, the soil is highly cultivated; and through the abundant harvests the people enjoy greater prosperity than in most of the other provinces. Fowls are largely exported to England. The silk cultivation provides occupation for the urban population, and several small cities, like Osimo, Jesi, and Chiaravalle, depend almost entirely upon this industry. Another important branch of activity is the paper industry. Chiaravalle possesses one of the largest tobacco factories of the Italian *Régie*. Limestone quarries and sulphur mines supply building stone and sulphur to the regions of Central Italy. The Adriatic shore and the adjacent districts provide the wealthy with favourite summer resorts. As regards maritime trade the province possesses facilities in the port of Ancona, the canal port of Sinigaglia, and other smaller harbours chiefly used by fishing boats. Fishing is carried on by the entire coast population, which furnishes a large contingent of sailors to the Italian navy. The character of the country population is quiet and peaceable. All are fervent Roman Catholics.

Ancona, an Italian city, capital of the province of the same name, pleasantly situated upon the Adriatic about 124 miles from Bologna and more than 186 miles from Rome. The extensive works undertaken by the Italian Government in order to enlarge the fortifications and to purify some quarters of the city have considerably changed its aspect, which is now rendered more pleasing by wide streets and esplanades. The Gothic façade of the cathedral is among the most beautiful in Italy. There is a lazzaretto begun by Pope Clement XII. and finished by Pius VI., to whom is also due the finest street of the city and an arch (Porta Pia), by Vanvitelli. The chief monuments are those to Clement XII. and to Cavour. The municipal palace dates from 1270, and contains a valuable picture gallery and library. The Merchants' Guild and the Theatre of the Muses display exquisite workmanship. Several large bathing establishments, thoroughly modernized, are thronged by visitors in the summer months. The smaller triumphal arch erected near to that in honour of Trajan is dedicated to Pope Clement XIV., who reconstructed and enlarged the harbour and declared Ancona a free port (it is so no longer) in the 18th century. Its two moles and dredging works confer upon the port (which is furnished with a powerful lighthouse) great security and a considerable anchorage. There is an arsenal and a dockyard. Numbers of mercantile steamships are constructed, and important commissions are executed for the Italian navy every year. Trade has now regained its former volume, and the receipts of the Customs House are but little inferior to those of Venice. In 1898 commerce comprised 235,000 tons of seaborne and 32,000 tons of land imports; 48,000 tons of exports by sea and 23,000 tons by land; steamers visiting the port, 599 (of which 60 were British); sailing vessels, 468. Ancona is in direct steamship communication with the chief European countries, as well as with Asia Minor, Tunis, India, and South America. The chief manufactures are metallurgy (the arsenal alone employs 2000 workmen), sugar refining (1000 workmen), compressed coal, soapmaking, tanning, and silk-spinning. Though the great majority of the people belong to the monarchical party, Ancona is considered the headquarters of anarchism. According to Pliny, Ancona was founded by the Dorians about 1500 B.C. Population (1901), 56,825.

Andaman Islands.—These islands lie in the Bay of Bengal, 120 miles from Cape Negrais in British Burma. The southernmost, Little Andaman (26 miles by 16), is separated by a passage 31 miles wide from Rutland Island (11 miles long), which in turn is the southernmost of a group of five main islands together forming the Great Andaman. North of Rutland Island is South Andaman (49 miles), and for 17 miles from the north end, and parallel to the east shore of this, runs an island called Baratang. Beyond these again stretch Middle Andaman (59 miles), and North Andaman (51 miles). Between the North and Middle Andamans lies Austen Strait; between Middle Andaman and the north extremities of South Andaman and Baratang, Homfray's Strait; between South Andaman and Baratang, Middle (or Andaman) Strait; and between South Andaman and Rutland Island, Macpherson's Strait, the only one of the four navigable by ocean-going vessels. The sea all around is most difficult of navigation, but there are a number of safe harbours and anchorages around Great Andaman, and the charts generally were much improved by a survey in 1888-89, the chart resulting from which is in turn being continually amended. The whole group was completely surveyed topographically in 1883-86, when accurate maps on the scale of 2 miles to the inch were produced. The neighbourhood of Port Blair was mapped on a scale eight times as large.

Geology.—Preliminary examinations undertaken by official experts have afforded all that is yet known of the geology. The submarine ridges forming these islands contain much that is characteristic of the Arakan Yomas and formations common to the Nicobars, Sumatra, and the islands off Sumatra. The older rocks are probably early Tertiary or late Cretaceous, but there are no fossils to indicate age. The newer rocks are in the Archipelago chiefly and contain radiolarians and foraminifera. A theory of the subsidence of the islands seems established; it appears to be of recent origin and signs of its continuance are to be found at several places. Though lying along a recognized subterranean line of weakness, the islands have, since the British occupation (1858) at least, been entirely free from earthquakes of great violence, but shocks are felt at more or less frequent intervals. Narcondam (extinct) and Barren Island are volcanoes of the general Sunda group. The sea-shells are not specially distinctive, but the land-shells are more noteworthy.

Meteorology.—Rarely affected by a cyclone, though within the influence of practically every one that blows in the Bay of Bengal, the Andamans are of the greatest importance because of the accurate information relating to the direction and intensity of storms which can be communicated from them, better than from any other point in the Bay, to the vast amount of shipping in this part of the Indian Ocean. Trustworthy information, also, regarding the weather which may be expected in the north and east of India is obtained at the islands, and this proves of the utmost value to the controllers of the great trades dependent upon the rainfall. A well-appointed meteorological station has been established at Port Blair since 1868. Speaking generally, the climate of the Andamans themselves may be described as normal for tropical islands of similar latitude. Not only does the rainfall at one place vary from year to year, but there is an extraordinary difference in the returns for places quite close to one another. The official figures in inches for the station at Port Blair, which is situated in by far the driest part of the settlement, were:

1895.	1896.	1897.	1898.	1899.
125·64	107·28	136·41	127·22	87·01

The mean highest temperature in the shade in 1895 (April) was 90·1° F.; in 1897 (April), 94° F.; in 1899 (March), 91·8° F. The mean lowest temperature in the shade in 1895 (February) was 70·9° F.; in 1897 (January), 72·5° F.; in 1899 (February), 71·2° F. A tidal observatory has also been maintained at Port Blair since 1880.

Forests.—In the forests which cover the Great Andaman the timber available for economic purposes is both plentiful and varied and the supply is only limited by the difficulty of obtaining labour. A section of the general forest department of India has been established in the islands, and 156 square miles have been formally set apart for regular forest operations in the neighbourhood of Port Blair. There is, however, no indigenous labour whatever, and the working of this area is entirely carried out by the convicts in the penal settlement. There is an export trade in timber both to Calcutta and to Europe, and the Andaman Padouk is so highly valued in European markets as a substitute for mahogany that a spurious imitation known as African Padouk has been exploited. Tea is grown in considerable quantities, and the cultivation is under a department of the penal settlement. The output in 1895 was 145,203 lb; in 1897, 121,066 lb; in 1899, 154,004 lb.

Animals.—Of imported animals, cattle, goats, asses, and dogs thrive well; ponies and horses, indifferently; sheep, badly, though some success has been achieved in breeding them.

Aborigines.—The policy of conciliation unremittingly pursued for the last forty years has now secured a friendly reception for shipwrecked crews at any port of the islands except the south and west of Little Andaman and North Sentinel Island. The population is not susceptible of census, but probably it has always been small. Local expert guesses do not now place it higher than from 2500 to 3500, and though it is commonly asserted that the natives are going down before superior civilization, it is doubtful whether, except in the immediate neighbourhood of the penal settlement, there is as yet any permanent change in their numbers. Though all descended from one stock, there are ten distinct tribes of the Andamanese, each with its own clearly defined locality, its own distinct variety of the one fundamental language, and to a certain extent its own separate habits. Every tribe is divided into septs fairly well defined. The tribal feeling may be expressed as friendly within the tribe, courteous to other Andamanese if known, hostile to every stranger, Andamanese or other. Another division of the natives is into *Aryauto* or long-shore-men, and the *Eremtaga* or jungle-dwellers. The habits and capacities of these two differ, owing to surroundings, irrespectively of tribe. Yet again the Andamanese can be grouped according to certain salient characteristics: the forms of the bows and arrows, of the canoes, of ornaments and utensils, of tattooing, and of language. The average height of males is 4 ft. 10½ in.; of females, 4 ft. 6 in. Being accustomed to gratify every sensation as it arises, they endure thirst, hunger, want of sleep, and bodily discomfort badly. The skin varies in colour from an intense sheeny black to a reddish-brown on the collar-bones, cheeks, and other parts of the body. The hair varies from a sooty black to dark and light brown and red. It grows in small rings, which give it the appearance of growing in tufts, though it is really closely and evenly distributed over the whole scalp. The figures of the men are muscular and well-formed, and generally pleasing; a straight, well-formed nose and jaw are by no means rare, and the young men are often distinctly good-looking. The only artificial deformity is a depression of the skull, chiefly among one of the southern tribes, caused by the pressure of a strap used for carrying loads. The pleasing appearance natural to the men is not a characteristic of the women, who early have a tendency to stoutness and ungainliness of figure, and sometimes to pronounced prognathism. They are, however, always bright and merry, are under no special social restrictions, and have considerable influence. The women's heads are shaved entirely, and the men's into fantastic patterns. Yellow and red ochre mixed with grease are coarsely smeared over the bodies, grey in coarse patterns, and white in fine patterns resembling tattoo marks. Tattooing is of two distinct varieties. In the south the body is slightly cut by women with small flakes of glass or quartz in zigzag or lineal patterns downwards. In the north it is deeply cut by men with pig-arrows in lines across the body. The male matures when about fifteen years of age, marries when about twenty-six, begins to age when about forty, and lives on to sixty or sixty-five if he reaches old age. Except as to the marrying age, these figures fairly apply to women. Before marriage free intercourse between the sexes is the rule, though certain conventional precautions are taken to prevent it. Marriages rarely produce more than three children, and often none at all. Divorce is rare, unfaithfulness after marriage not common, and incest unknown. By preference the Andamanese are exogamous as regards sept and endogamous as regards tribe. The children are possessed of a bright intelligence, which, however, soon reaches its climax, and the adult may be compared in this respect with the civilized child of ten or twelve. The Andamanese are, indeed, bright and merry companions, busy in their own pursuits, keen sportsmen, naturally independent, and not lustful, but when angered, cruel, jealous, treacherous, and vindictive, and always unstable—in fact, a people to like but not to trust. There is no idea of government, but in each sept there is a head, who has attained that position by degrees on account of some tacitly admitted superiority and commands a limited respect and some obedience. The young are deferential to their elders. Offences are punished by the aggrieved party. Property is communal, and theft is only recognized as to things of absolute necessity, such as arrows, pig's flesh, and fire. Fire is the one thing they are really careful about, not knowing how to renew it. A very rude barter exists between tribes of the same group in regard to articles not locally obtainable. The religion consists of fear of the spirits of the wood, the sea, disease, and ancestors, and of avoidance of acts traditionally displeasing to them. There is neither worship nor propitiation. An anthropomorphic deity, Puluga, is the cause of all things, but it is not necessary to propitiate him. There is a vague idea that the "soul" will go somewhere after death, but there is no heaven nor hell, nor idea of a corporeal resurrection. There is much faith in dreams, and in the utterances of certain "wise men," who practise an embryonic magic and witchcraft. The great amusement of the Andamanese is a formal night dance, but they are also fond of simple games. The bows differ altogether with each group, but the same two kinds of arrows are in general use: (1) long and ordinary for fishing and other purposes; (2) short with a detachable head fastened to the shaft by a thong, which quickly brings pigs up short when shot in the thick jungle. Bark provides material for string, while baskets and mats are neatly and stoutly made from canes, and buckets out of bamboo and wood. None of the tribes ever ventures out of sight of land, and they have no idea of steering by sun or stars. Their canoes are simply hollowed out of trunks with the adze and in no other way, and it is the smaller ones which are outrigged; they do not last long and are not good sea boats, and the story of raids on Car Nicobar, out of sight across a stormy and sea-rippled channel, must be discredited. Honour is shown to an adult when he dies, by wrapping him in a cloth and placing him on a platform in a tree instead of burying him. At such a time the encampment is deserted for three months. The Andaman languages are extremely interesting from the philological standpoint. They are agglutinative in nature, show hardly any signs of syntactical growth, though every indication of long etymological growth, give expression to only the most direct and the simplest thought, and are purely colloquial and wanting in the modifications always necessary for communication by writing. The sense is largely eked out by manner and action. *Mincopie* is the first word in Colebrooke's vocabulary for "Andaman Island, or native country," and the term has thus become a persistent book-name for the people. It, or something like it, was probably one of the tribal names when Colebrooke wrote 120 years ago, and may be used now, but this cannot be ascertained. Attempts to civilize the Andamanese have met with little success either among adults or children. The home established near Port Blair is used as a sort of free asylum which the native visits according to his pleasure. The policy of the government is to leave the Andamanese alone, while doing what is possible to ameliorate their condition.

Penal Settlement.—The point of enduring interest as regards the Andamans is the penal system, the object of which is to turn the life-sentence and few long-sentence convicts, who alone are sent to the settlement, into honest, self-respecting men and women, by leading them along a continuous course of practice in self-help and self-restraint, and by offering them every inducement to take advantage of that practice. After ten years' graduated labour the convict is given a ticket-of-leave and becomes self-supporting. He can farm, keep cattle, and marry or send for his family, but he cannot leave the settlement or be idle. With approved conduct, however, he may be absolutely released after twenty to twenty-five years in the settlement; and throughout that time, though possessing no civil rights, a quasi-judicial procedure controls all punishments inflicted upon him, and he is as secure of obtaining justice as if free. There is an unlimited variety of work for the labouring convicts, and some of the establishments are on a large scale. The general and marine steam and hand workshops employ 574 men; 72,000 burnt bricks are turned out daily during the season; in building the Cellular Jail some 30,000,000 bricks were used. Very few experts are employed in supervision; practically everything is directed by the officials, who themselves have first to learn each trade. Under the Chief Commissioner, who is the supreme head of the settlement, are a deputy and a staff of assistant superintendents and overseers, almost all Europeans, and sub-overseers, who are natives of India. All the petty supervising establishments are composed of convicts. The garrison consists of 140 British and 300 Indian troops, with a few local European volunteers. The police are organized as a military battalion 643 strong. The number of convicts has somewhat diminished of late years, and in 1900 stood at something over 11,000. The total population of the settlement, consisting of convicts, their guards, the supervising, clerical, and departmental staff, with the families of the latter, also a certain number of ex-convicts and trading settlers and their families, numbers about 13,000 males and 2000 females. The labouring convicts are distributed among four jails and nineteen stations; the self-supporters in thirty-eight villages. The elementary education of the convicts' children is compulsory. There are four hospitals, each under a resident medical officer, under the general supervision of a senior officer of the Indian Medical Service, and medical aid is given free to the whole population. The harbour of Port Blair is well supplied with buoys and harbour lights, and is crossed by ferries at fixed intervals, while there are several launches for hauling local traffic. On Ross Island there is a lighthouse visible for nineteen miles. A complete system of signalling by night and day on the Morse system is worked by the police. Local posts are frequent, but there is no telegraph, and the mails are irregular. A system of wireless telegraphic communication with India is in contemplation. In 1898 there were among the convicts 36 Christians, 2752 Mahommedans, 6585 Hindus, 1758 Buddhists, and 70 others. The convict death-rate was 25 per 1000, and 173 were set free after twenty to twenty-five years' average transportation. 265 children attended the school. Of 88 applications for permission to marry, 47 were granted. The total receipts (actual cash from timber, &c., apart from the value of the convict labour as such) in 1898 amounted to £36,359, as compared with only £27,826 in 1894, but with £50,421 in 1897. Expenditure, on the other hand, in 1898 amounted to £103,861, as compared with only £93,963 in 1894, but with £112,170 in 1897. Thus the net cost to Government in 1898 was £67,502; and the net annual cost per convict, £6·1. The variation in the amounts for different years is largely due to the fact that the forest year does not coincide with the revenue year, and to the great distance from London, whence payments are made.

Authorities.—Since 1875 there has been extensive research into the Andamanese and their country. The following books will be found to contain most of the necessary references:—Man. *Aboriginal Inhabitants of the Andaman Islands.* London, 1883.—Portman. *History of our Relations with the Andamanese.* Calcutta, Government, 1899; *Notes on the Languages of the South Andaman Group of Tribes.* Calcutta, Government, 1898; and *Record of the Andamanese.* xi. vols. MS. India Office, London, and Home Department, Calcutta.—De Folin. *Mollusques des Îles Andamans.* Bordeaux, 1879.—Temple. *Commercial Value of Wireless Telegraphic Communication with the Andaman and Nicobar Islands.* Calcutta, 1899. (R. C. T.)

Anderlecht, a town of Belgium, in the province of Brabant, 3 miles W. of Brussels, with numerous manufactures. It was formerly a part of Brussels, but was erected into a separate commune in 1895. Population (communal) (1897), 41,862.

Andersen, Hans Christian (1805-1875), Danish poet and fabulist, born at Odense, in Funen, on the 2nd of April 1805. He was the son of a sickly young shoemaker of twenty-two, and his still younger wife: the whole family lived and slept in one little room. Andersen very early showed signs of imaginative temperament, which was fostered by the indulgence and superstition of his parents. In 1816 the shoemaker died, and the child was left entirely to his own devices. He ceased to go to school; he built himself a little toy-theatre, and sat at home making clothes for his puppets, and reading all the plays that he could borrow; among them were those of Holberg and Shakespeare. At Easter 1819 he was confirmed at the church of St. Kund, Odense, and began to turn his thoughts to the future. It was thought that he was best fitted to be a tailor; but as nothing was settled, and as Andersen wished to be an opera-singer, he took matters into his own hand, and started for Copenhagen in September 1819. There he was taken for a lunatic, snubbed at the theatres, and nearly reduced to starvation, but he was befriended by the musicians Weyse and Siboni, and afterwards by the poet Guldberg. His voice failed, but he was admitted as a dancing pupil at the Royal Theatre. He grew idle, and lost the favour of Guldberg, but a new patron appeared in the person of Jonas Collin, the director of the Royal Theatre, who became Andersen's life-long friend. King Frederick VI. was interested in the strange boy, and sent him for some years, free of charge, to the great grammar-school at Slagelse. Before he started for school he published his first volume, *The Ghost at Palnatoke's Grave*, 1822. Andersen, a very backward and unwilling pupil, actually remained at Slagelse and at another school in Elsinore until 1827; these years, he says, were the darkest and bitterest in his life. Collin at length consented to consider him educated, and Andersen came to Copenhagen. In 1829 he made a considerable success with a fantastic volume entitled *A Journey on Foot from Holman's Canal to the East Point of Amager*, and he published in the same season a farce and a book of poems. He thus suddenly came into request at the moment when his friends had decided that no good thing would ever come out of his early eccentricity and vivacity. He made little further progress, however, until 1833, when he received a small travelling stipend from the king, and made the first of his long European journeys. At Le Locle, in the Jura, he wrote *Agnate and the Merman*; and in October 1834 he arrived in Rome. Early in 1835 Andersen's novel, *The Improvisatore*, appeared, and achieved a real success; the poet's troubles were at an end at last. In the same year, 1835, the earliest instalment of Andersen's immortal *Fairy Tales* (Eventyr) was published in Copenhagen. Other parts, completing the first volume, appeared in 1836 and 1837. The value of these stories was not at first perceived, and they sold slowly. Andersen was more successful for the time being with a novel, *O. T.*, and a volume of sketches, *In Sweden*; in 1837 he produced the best of his romances, *Only a Fiddler*. He now turned his attention, with but ephemeral success, to the theatre, but was recalled to his true genius in the charming miscellanies of 1840 and 1842, the *Picture-Book without Pictures*, and *A Poet's Bazaar*. Meanwhile the fame of his *Fairy Tales* had been steadily rising; a second series began in 1838, a third in 1845. Andersen was now celebrated throughout Europe, although in Denmark itself there was still some resistance to his pretensions. In June 1847 he paid his first visit to England, and enjoyed a triumphal social success; when he left, Charles Dickens saw him off from Ramsgate Pier. After this Andersen continued to publish much; he still desired to excel as a novelist and a dramatist, which he could not do, and he still disdained the enchanting *Fairy Tales*, in the composition of which his unique genius lay. Nevertheless he continued to write them, and in 1847 and 1848 two fresh volumes appeared. After a long silence Andersen published in 1857 another romance, *To be or not to be*. In 1863, after a very interesting journey, he issued one of the best of his travel-books, *In Spain*. His *Fairy Tales* continued to appear, in instalments, until 1872, when, at Christmas, the last stories were published. In the spring of that year Andersen had an awkward accident, falling out of bed and severely hurting himself. He was never again quite well, but he lived till the 4th of August 1875, when he died very peacefully in the house called Rolighed, near Copenhagen. (E. G.)

Anderson, the capital of Madison county, Indiana, U.S.A., situated on the west fork of White river; a manufacturing city, at the intersection of three railways. Population (1900), 20,178.

Anderson, the capital of Anderson county, South Carolina, U.S.A., situated in the western part of the state, and surrounded by a fertile region, largely devoted to the production of cotton, of which this is a shipping point. It has three railways. Population (1900), 5498.

Anderson, Elizabeth Garrett (1836-——), English medical practitioner, daughter of Newson Garrett, of Aldeburgh, Suffolk, was born in 1836, and educated at home and at a private school. In 1860 she resolved to study medicine, an unheard-of thing for a woman in those days, and one which was regarded by old-fashioned people as almost indecent. Miss Garrett managed to obtain some more or less irregular instruction at the Middlesex Hospital, London, but was refused admission as a full student both there and at many other schools to which she applied. Finally she studied anatomy privately at the London Hospital, and with some of the professors at St Andrews University, and at the Edinburgh Extra-Mural School. She had no less difficulty in gaining a qualifying diploma to practise medicine. London University, the Royal Colleges of Physicians and Surgeons, and many other examining bodies, refused to admit her to their examinations; but in the end the Society of Apothecaries, London, allowed her to enter for the License of Apothecaries' Hall, which she obtained in 1865. In 1866 she was appointed general medical attendant to St Mary's Dispensary, a London institution started to enable poor women to obtain medical help from qualified practitioners of their own sex. The dispensary soon developed into the New Hospital for Women, and there she worked for over twenty years. In 1870 she obtained the Paris degree of M.D. The same year she was elected to the first London School Board, at the head of the poll for Marylebone, and was also made one of the visiting physicians of the East London Hospital for Children; but the duties of these two positions she found to be incompatible with her principal work, and she soon resigned them. In 1871 she married Mr J. G. S. Anderson, a shipowner, but did not give up practice. She worked steadily at the development of the New Hospital, and (from 1874) at the creation of a complete School of Medicine in London for women. Both institutions have since been handsomely and suitably housed and equipped, the New Hospital (in the Euston Road) being worked entirely by medical women, and the School (in Hunter Street, W.C.) having over 200 students, most of them preparing for the medical degree of London University, which was opened to women in 1877. In 1897 Mrs Garrett Anderson was elected president of the East Anglian branch of the British Medical Association. The movement for the admission of women to the medical profession, of which she was the indefatigable pioneer in England, has extended not only to every part of the United Kingdom and the British colonies, but to every European country except Spain and Turkey.

Andersonville, a village of Sumter county, Georgia, U.S.A., on the Central of Georgia railway. During the Civil War it was the site of a Confederate prison for Federal soldiers. It is now the site of a national cemetery.

Andes.—The Andes form a continuous chain of mountainous highland along the western coast of South America, which, roughly speaking, may be regarded as 4400 miles long, 100 miles wide in some parts, and of an average height of 13,000 feet. The connexion of this system with that of the Rocky Mountains, which has been pointed out by many writers, has received much support from the discovery of the extensive eruptions of granite during Tertiary times, extending from the southern extremity of South America to Alaska. The Andean range is composed of two great principal chains with a deep intermediate depression, in which, and at the sides of the great chains, arise other chains of minor importance, the chief of which is that called the Cordillera de la Costa of Chile. This starts from the southern extremity of the continent, and runs in a northerly direction, parallel with the coast, being broken up at its commencement into a number of islands, and afterwards forming the western boundary of the great central valley of Chile. To the north this coastal chain continues in small ridges or isolated hills along the Pacific as far as Colombia, always leaving the same valley more or less visible to the west of the western great chain. These mountains were the objects of important investigations during the last quarter of the 19th century.

Of the two principal chains, the eastern is generally called Los Andes, and the western La Cordillera, in Colombia, Peru, and Bolivia, where it is likewise known as Cordillera Real de Los Andes, whilst to the south of parallel 23° S. lat. in Chile and Argentina, the western is called Cordillera de los Andes. The eastern disappears in the centre of Argentina, and it is therefore only the Cordillera de los Andes that is prolonged as far as the south-eastern extremity of the continent. The Cordillera de la Costa begins near Cape Horn, which is composed principally of crystalline rocks, and its heights are inconsiderable when compared with those of the true Cordillera of the Andes. The latter, as regards its main chain, is on the northern coast of Beagle Channel, in Tierra del Fuego, bounded on the north by the deep depression of Lake Fagnano and of Admiralty Sound. Staten Island appears to be the termination to the east. The Cordillera of the Andes in Tierra del Fuego is formed of crystalline schists, and culminates in the snow-capped peaks of Mount Darwin and Mount Sarmiento (7200 feet), which contains glaciers of greater extent than those of Mont Blanc. Sir Martin Conway recently ascended the latter. The extent of the glaciers is considerable in this region, which, geographically, is more complex than has hitherto been supposed. Although, in the explored portion of the Fuegian chain, the volcanoes which have been mentioned from time to time have not been met with, there seems to have existed to the south, on the islands, many neo-volcanic rocks, some of which appear to be contemporaneous with the basaltic sheet that covers a part of Eastern Patagonia. The insular region between Mount Sarmiento and the Cordillera de los Andes, properly so called, *i.e.*, that which extends from Magellan Strait northwards, has not been explored, and all that is known of it is that it is principally composed of the same rocks as the Fuegian section, and that the greater part of its upper valleys is occupied by glaciers that reach down to the sea amid dense forest.

As Admiralty Sound and Lake Fagnano, the extent of which is still unknown, bound the Cordillera to the north in Tierra del Fuego, so at the eastern side of the Cordillera in Patagonia there is a longitudinal depression which separates the Andes from some independent ridges pertaining to a secondary parallel broken chain called pre-Cordillera. This depression is occupied in a great part by a series of lakes, some of these filling transversal breaches in the range, whilst others are remains of glacial reservoirs, bordered by morainic dams, extending as far as the eastern tableland and corresponding in these cases with transversal depressions which reach the Atlantic Ocean. Between the larger lakes, fed by the Andine glaciers of the eastern slope of the Southern Andes, are Lakes Maravilla, 100 square miles, and Sarmiento, 26 square miles, 51° S. lat., which overflow into Last Hope Inlet; Argentino, 570 square miles, 50° S. lat.; and Viedma, 450 square miles, 49° 30′ S. lat., which empty into the river Santa Cruz; the fiordian Lake Sao Martin, 49° S. lat.; and Lakes Nansen, 18 square miles; Azara, 8 square miles; and Belgrano, 16 square miles, which are dependants of Lake San Martin (380 square miles), and Lakes Pueyrredon (98 square miles) and Buenos Aires (700 square miles), and which now overflow into the Pacific, through one of the remarkable inlets that are found throughout the Cordillera, the Calen Inlet, which is the largest western fiord of Patagonia. To the north of Lake Buenos Aires there is Lake Elizalde, which, while situated on the eastern slope sends its waters to the Pacific Ocean, and Lakes Fontana (30 square miles) and La Plata (34 square miles), 45° S. lat., which feed the river Senguerr, which flows to the Atlantic. Lake General Paz (66 square miles) on the eastern slope of the Andes, at 44° S. lat., is the principal source of the Palena river, which cuts all the Cordillera, while Lakes Fetalanquen (20 square miles), Menendez (28 square miles), Rivadavia (10 square miles), and other smaller lakes, also situated between 43° 30′, and 42° 30′ S. lat. on the eastern slope, send their waters to the Pacific by the river Fetaleufu, which cuts through the Andes by a narrow gorge. The waters of Lake Puelo (18 square miles) likewise flow into the same ocean through the river of that name, which also cuts the Cordillera, and of which the principal affluent likewise drains the waters of a system of small lakes, the largest of which, Lake Mascardi, measures 17 square miles, which in comparatively recent times formed part of the basin of Lake Nahnel-Huapi (207 square miles), 41° S. lat. An extensive area of glacial deposits shows that a sheet of ice formerly covered the whole eastern slope to a great distance from the mountains. To the west another sheet reached at the same time the Pacific Ocean.

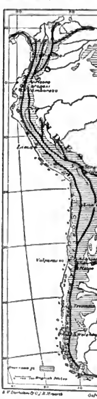
From the Strait of Magellan up to 52° S. lat., the western slope of the Cordillera does not, properly speaking, exist. Abrupt walls overlook the Pacific, and great longitudinal and transversal channels and fiords run right through the heart of the range, cutting it generally in a direction more or less oblique to its axis, the result of movements of the earth's crust.

The mountains forming the Cordillera between Magellan Strait and 41° S. lat. are higher than those previously mentioned in Tierra del Fuego. Generally composed of granite, gneiss, and Palæozoic rocks, covered in many parts by rugged masses of volcanic origin, their general height is not less than 6500 feet, while Mount Geikie is 7500 feet and Mount Stokes 7100 feet high. To the north are Mounts Mayo, 7600 feet; Agassiz, 10,600 feet; and Fitz Roy, in 49° S. lat., 11,120 feet high. The section from 52° to 48° S. lat. is a continuous ice-capped mountain range, and some of the glaciers extend from the eastern lakes to the western channels, where they reach the sea-level. The level of the lakes commences at 130 feet at Lake Maravilla and gradually ascends to near 700 feet at Lake San Martin. Passing the breach through which Lake San Martin empties itself into Calen Inlet, in 48° S. lat., is found a wide oblique opening in the range, through which flows the river Las Heras, fed by Lake Pueyrredon, which is only 410 feet above the sea-level to the east of the Andes, while Lake Buenos Aires, immediately to the north, is 710 feet. The Andes continue to be to the west an enormous rugged mass of ice and snow of an average height of 9000 feet, sending glaciers to all the eastern fiords.

Mount San Lorenzo, detached from the main chain in the pre-Cordillera, is 11,800 feet high. Mount Sao Valentin, 12,700 feet, is the culminating point of the Andes in the region extending from 49° to 46° S. lat., where another breach occurs, that of the river Huemules, which is supposed to be the outlet of Lake Elizalde to the east, and is followed by that of the river Aysen. These two breaches have emptied a large system of lakes, which, in pre-Glacial times, occupied the eastern zone, thus forming a region suitable for colonization in the broad valleys and hollows, where the rivers, as is the case with those in the north, cut through the Andes by narrow gaps, forming cataracts and rapids between the snowy peaks. Volcanic action is still going on in these latitudes, as the glaciers are at times covered by ashes, but the predominant rocks to the east are the Tertiary granite, while to the west gneiss, older granite, and Palæozoic rocks prevail. The highest peaks, however, seem to be of volcanic origin. Farther north, up to 41° S. lat., the water gaps are situated at a lesser distance one from the other, owing mainly to more continuous erosion, this section of the continent being the region of the maximum rainfall on the western coast to the south of the equator. Between the gaps of the river Aysen and river Cisnes or Frias, which also pierces the chain, is found a huge mountain mass, in which is situated Mount la Torre, 7150 feet. These form the continental watershed, but in this region erosion is taking place so rapidly that the day is not far distant when Lakes La Plata and Fontana, situated to the east at a height of 3000 feet, and now tributaries of the Atlantic, may become tributaries of the Pacific. Already filtrations from the former go to feed western affluents through the granitic masses. To the north of Mount La Torre flows in the river Cisnes, 44° 48′ S. lat., across another water gap, continuing the range to the north with high peaks, as Alto Nevado, 7350 feet, and Cacique, 7000 feet. The glaciers reach almost the western channels, as is the case at river Quelal. The northern glaciers, descending nearly to sea-level, are situated at 43° 40′ S. lat. To the north of 45° S. lat. a well-defined western longitudinal valley, at some recent time occupied by lakes and rivers, divides the Cordillera into two chains, the eastern being the main chain, to which belong Mounts Alto Nevado, Cacique, Deutista, Maldonado, Serrano, each over 7000 feet high; Torrecillas, 7400 feet; Ventisquero, 7500 feet; and Tronador, 11,180 feet; while the western chain, broken into imposing blocks, contains several high volcanic peaks such as Mounts Tanteles, Corcovado, Minchimahuida, Hornopiren, and Yates. The rivers Palena, with its two branches, Picu and Carrenleufu, Fetaleufu, Puelo, and Manso, cut the two chains, while the rivers Reñihue, Bodadahue, and Cochamo have their sources in the main eastern ridge. Mention has been made of active volcanoes in 51°, 49°, and 47° S. lat., but these have not been properly located. The active volcanoes south of 41°, concerning which no doubt exists, are the Huequen, in 43° lat., and the Calbuco, both of which have been in eruption during recent years.

The surroundings of Mount Tronador, consisting of Tertiary granite and basalt, form one of the most interesting regions in the Patagonian Andes for the mountaineers of the future. To the east extends the large and picturesque lake of Nahuel-Huapi, to the west is Lake Todos Los Santos (50 square miles), to which the access is easy and of which the scenery is of surpassing beauty. Between 41° and 38° S. lat., among other smaller lakes, are Lakes Traful (45 square miles), Lacar (32 square miles), which, properly belonging to the system of Atlantic lakes, empties itself by the only water gap that occurs in this zone of the Cordillera into the river Valdivia, a tributary of the Pacific, Lake Lolog (15 square miles), Huechu-lafquen (45 square miles), and Lake Alumine (21 square miles). The volcanoes of Lanin, 12,140 feet; Quetropillan, 9180 feet; Villarica, 10,400 feet; Yaimas and Tolhuaca are all more or less active; the first is in the main chain, while the others are on the western slope. The scenery in the neighbourhood is magnificent, the snowy cones rising from amidst woods of araucaria, and being surrounded by blue lakes. While the scenery of the western slope of the Andes is exceedingly grand, with its deep fiords, glaciers, and woods, yet the severity of its climate detracts considerably from its charm. The climate of the eastern slope, however, is milder, the landscapes are magnificent, with wooded valleys and beautiful lakes. The valleys are already partly settled by colonists. Between 52° and 40° S. lat. the erosion (fractures of the earth's crust) has carried the watershed of the continent from the summit of the Cordillera to the eastern plains of Patagonia.

Between 36° and 33° S. lat. the Andes have been somewhat extensively explored during the last ten years by the Argentine and Chilian Boundary Commissions. The highest peaks are volcanic, and their eruptions have sensibly modified the character of the primitive ridges. Outflows of lava and tufa cover the mountain sides and fill up the valleys. The Jurassic and Cretaceous formations, which, in the Southern Cordillera are situated outside of the range to the east, form to a considerable extent the mass of the great range, together with porphyric quartz, the Tertiary, granite, and other eruptive rocks, which have been observed along all the chain in South America up to Alaska in the north. Gneiss is seldom met with, but there are crystalline rocks, belonging chiefly to the pre-Cordillera of the eastern, and to the Cordillera de la Costa on the western side. Silurian, Devonian, and Carboniferous rocks contribute to the formation of the pre-Cordillera, between 30° and 33° S. lat.



SCHEME OF THE ANDES RANGE.

Whilst the axis of the Cordillera de los Andes from the south as far as 38° S. lat. is crystalline, to the north of this latitude the geological features change. At this point the range takes a vast transversal development, dividing itself into three separate groups, the easternmost being composed of Jurassic-Cretaceous beds, the central of Mesozoic layers and old eruptive rocks, the western of Tertiary granitic formation, with neo-volcanic lavas and active volcanoes on its western border. From the volcano of Copahue (height 9787 feet) the Andes take a great transversal extension; there are no wide intermediate valleys between the different ridges, but the main ridge is perfectly defined. Volcanic cones continue to predominate, the old crystalline rocks almost disappear, while the Mesozoic rocks are most common. The higher peaks are in the main chain, whilst the Domuyo (15,317 feet) belongs to a lateral eastern ridge. The principal peaks between this and Mount Tupungato at 33° S. lat. are: Mount Cochico, 8255 feet; Campanario, 13,140 feet; Peteroa, 13,297 feet; Tinguiririca, Castillo, 16,535 feet; Volcano Maipu, 17,576 feet; Alvarado, 14,600 feet; Amarillo, 15,321 feet; Volcano San Jose, 19,849 feet; Piuquenes, 17,815 feet; and Volcano Bravard, 19,619 feet.

North of Maipu volcano, ascended by Dr Gussfeldt in 1883, the Cordillera is composed of two very huge principal ridges which unite and terminate in the neighbourhood of Mount Tupungato. The valley between them is 9000 feet high; and in that part of the Cordillera are situated the highest passes south of 33° S. lat., one of which, the Piuquenes Pass, reaches 13,333 feet, whilst the easiest of transit and almost the lowest is that of Pichachen, 6505 feet, which is the most frequented during winter. Throughout these regions the passes are numerous and of easy access in summer, but in winter they are generally dangerous.

To judge by certain features of this section of the Andes, it would seem that down to modern times, there existed across these mountains very low passes, through which some representatives of the Pampean fauna, such as the Mastodon and Equus, reached Chile, the remains of which have been discovered in the central valley of that country. The Andean glaciers at that time spread themselves down to the plain at the foot of the two slopes which then contained vast lakes, and where now exist extensive moraines and large erratic boulders. Mount Tupungato reaches 22,329 feet, according to Argentine measurement. To the north of this mountain, situated at the watershed of the Andes, extends a lofty region comprising peaks such as Chimbote, 18,645 feet, and Mount Polleras, 20,266 feet. The Pircas Pass is situated at a height of 16,962 feet. The gaps of Bermejo and Iglesia, in the Uspallata road, the best known of all the passes between Argentina and Chile, are at 13,025 feet and 13,412 feet altitude respectively, while the nearest peaks, those of Juncal and Tolosa, are 19,358 and 20,140 feet high. Mounts Tupungato, Aconcagua, 23,393 feet, ascended lately by Mr Fitzgerald, Mr Vines, and Sir Martin Conway, and Mercedario, 21,982 feet, are the highest peaks of the central Argentine-Chilian Andes. These three peaks are formed of eruptive rocks, surrounded by Jurassic beds which have undergone a thorough metamorphosis. While in the west of the Andes, from the latitude of Aconcagua, the central valley of Chile runs without any notable interruption to the south end of the continent, a valley which almost disappears to the north, leaving only some rare inflexions which are considered by the Chilian geographers and geologists to be a continuation of the same valley; to the east in Argentine there commenced a longitudinal valley perfectly characterized, which runs along the eastern foot of the Cordillera separating this from the pre-Cordillera, which is parallel to the Cordillera de la Costa of Chile. Between Aconcagua and Mercedario are the passes of Espinacito, 14,803 feet, and Los Patos or Valle Hermoso, 11,736 feet, chosen by the Argentine General San Martin, when he made his memorable passage across the chain during the War of Independence. North of Valle Hermoso the Andean ridges, while very high, are not abrupt, and the passes are more numerous than in the south; some of them descending 10,000 feet, but most of them carrying between 13,000 and 14,000 feet. Pass

Quebrada Grande is 12,468 feet in altitude; Cencerro, 12,944 feet; Mercedario, 13,206 feet; Ojota, 14,304 feet; Pachon, 14,485 feet; while Gordito is 10,318 feet. Farther north the passes are higher. Barahona Pass is 15,092 feet; Ternera, 15,912 feet; San Lorenzo, 16,420 feet, while the peak of the volcano reaches 18,148 feet; Mount Olivares, 20,472 feet; Porongos, 19,488 feet; Tortolas, 20,121 feet; and Potro, 19,357 feet.

As far as 28° S. lat. the Cordillera de los Andes has been principally formed by two well-defined ridges, but to the north, recent volcanic action has greatly modified its orography. Only a single line of passes characterizes the main ridge, and amongst them are the passes of Oiiita, 15,026 feet; Peñas Negras, 14,435 feet; Pircas Negras, 13,615 feet; La Gallina, 16,240 feet; Tres Quebradas, 15,535 feet; and Aguita, 15,485 feet. To the north of Mount Potro the peaks in the Cordillera are not very prominent as far as the great mass of Tres Quebradas, but here are to be met with some that may be considered as amongst the highest of the whole range. Mount Aguita is 20,600 feet, and the culminating peak of those of Tres Cruces reaches 22,658 feet. To the east of the eastern longitudinal valley, at 27° S. lat., commences a high volcanic plateau between the Cordillera and the southern prolongation of the Bolivian Cordillera Real, which contains lofty summits, such as Mount Veladero (20,998), Mount Bonete (21,980), Mount Reclus (20,670), Mount Pissis (22,146), Mount Ojo del Salado (21,653), and Incahuasi (21,719). To the north of Tres Cruces is a transversal depression in the Cordillera, which is considered to be the southern termination of the high plateau of the Puna de Atacama. The Cordillera of the Andes borders the Puna to the west, while the Bolivian Cordillera Real bounds it to the east. In that region the Cordillera of the Andes is of comparatively recent origin, being principally constituted by a line of high volcanoes, the chief summits being those of Juncal, Panteon de Aliete, Azufre or Listarria (18,636), Lullaillaco (21,720), Miñiques (19,357), Socompa (19,948), Licancaur (19,685), Viscachuelas (20,605), Tapaquilcha (19,520), Oyahua (19,242), Ancaquilcha (20,275), Oica (19,159), Miño (20,112), Sillilica (21,100), Perinacota (20,918), Sagama (22,339), Tacona (19,740), Misti (19,029); to the east closes in the intermediary high plateau which commences at 28° S. lat. in Argentina. The principal peaks of the Bolivian Andes and its prolongation from south to north, are Famatina, in the centre of Argentina, (20,340 feet), Laguna Blanca (18,307), Diamante (18,045), Cachi (20,000), Granadas, Lipez (19,680), Guadalupe (18,910), Chorolque (18,480), Cuzco (17,930), Enriaca (18,716), Junari (16,200), Michiga (17,410), Quimza-Cruz (18,280), Illimani (21,190), and Sorata (21,490), the last two of which were climbed by Sir Martin Conway.

While the western range of the Cordillera is principally formed by volcanic rocks, the eastern (to the east of the range is Cerro Potosi, 15,400 feet) Andes of Bolivia are chiefly composed of old crystalline rocks. Between the ranges in the high plateau north to 27° are numerous isolated volcanoes which have been in activity in recent times, such as Peinado (18,898 feet), San Pedro (18,701), Antoco (19,029), Antofalla (20,014), Rincon (17,881), Pastos Grandes (17,553), Zapaleri (17,553), Suniquira (19,258), Tahuc (17,458); volcanoes which have been elevated from a lacustrine basin, which very recently occupied the whole extension, and the remains of which are in the south, the Laguna Verde, at 28°, and in the north Lake Titicaca. The discovery of great Pampean mammals in the Pleistocene beds of that region shows that this upheaval of the latter is very recent, for in the heart of the Cordillera, as well as on the west coast of Bolivia and Peru, there have been discovered, in very recent deposits, the remains of some mammals which cannot have crossed the high range as it now exists.

The two Cordilleras that formed the Andes to the north of 28° S. lat. are continued in Peru, with the same characteristics—the western, chiefly volcanic, while its basis is crystalline; and the eastern composed of green mica slate, primitive clay-slate, and granite, the more important of the two, which is cut by many large rivers, affluents of the Amazon, and which abuts on Ecuador. The western, which reaches an altitude of about 10,000 feet, then ceases to exist as a continuous chain, there remaining only a short, high ridge, called by Whymper the "Pacific range of the equator," and between this ridge and the crystalline Andean axis, the "avenue of volcanoes," to use his words, arises amidst majestic scenery. Chimborazo, which is not in the main chain, reaches 20,517 feet, Cotopaxi (19,580 feet), Antisana (19,260 feet), Coyambo (19,200 feet), are in the eastern range, with many other peaks of over 16,000 feet, which still contain glaciers. Under the equator, Sangay, 17,380 feet, according to Wolff, appears to be the most active volcano in the world. Pichincha, 15,804 feet, and Cotocachi, 16,297 feet, are the loftiest volcanoes of the western range. The Colombian Andes have recently been the subject of careful exploration. The three principal chains are continuations of those under the equator, but show very slight traces of volcanic action. In the western chain, which is remarkable for its regularity, the highest peak is 11,150 feet, and the lowest pass 6725 feet. The longitudinal valley of Cauca forms the middle depression. The two chains appear to unite in the mountains of Antioquia. The eastern chain, separated from the central chain by the Magdelena depression, beginning north of the equator at 6000 feet, gradually rises to the height of Nevado, 14,146 feet, Pan de Azucar, 12,140 feet, and in the Sierra Nevada de Cochi attains to peaks of 16,700 feet. The predominant rocks are gneiss, crystalline slate, and granite, and some Cretaceous and Tertiary shales. The central chain is unbroken, and is the more important of the two, owing to its greater altitudes, and is of volcanic character. To the south, near the equator, are Mounts Arapul, 13,860 feet, and Chumbul, 15,720 feet. The volcanoes Campainero, 12,470 feet, and Pasto, 14,000 feet, are also in that zone. Farther north is the volcano Purace, which presents a height of 16,000 feet; then come Huila, 18,000 feet; Santa Catalina, 16,170 feet; and Tolima, 18,400 feet; Santa Isabel, 16,760 feet; Ruiz, 17,390 feet; and Hervas, 18,340 feet.

AUTHORITIES.—JOHN B. MINCHIN. "Journey in the Andean Tableland of Bolivia," *Proceedings of Geographical Society*, 1882. —Dr PAUL GUSSFELDT. *Reise in den Centralen Chileno-Argentinichen Andes.* Berlin, 1884.—JOHN BALL. *Notes of a Naturalist in South America.* London, 1887.—DR ALFRED HETTNER. *Reisen in den Colombianischen Andean.* Leipsic, 1888.—EDWARD WHYMPER. *Travels amongst the Great Andes of the Equator.* London, 1892.—TEODORO WOLFF. *Geografia y Geologia del Ecuador.* Leipsic, 1892.—E. A. FITZGERALD. *The Highest Andes.* London, 1899.—SIR MARTIN CONWAY. "Explorations in the Bolivian Andes," *Geographical Journal.* London, 1899. —Dr CARL BURCKHARD. "Expedition géologique dans la Région Andine, 38°-39° S. lat."—DR LEO WEHRLI. "Cordillère Argentino-Chilienne, 40° et 41° S. lat.," *Revista del Musea de La Plata*, 1899.—F. P. MORENO. "Explorations in Patagonia," *Geographical Journal.* London, 1900.—HANS STEFFEN. "The Patagonian Cordillera and its Main Rivers, between 41° and 48° S. lat." *Geographical Journal.* London, 1900.—PAUL KRUGER. *Die Chilenische Reñihue Expedition.* Berlin, 1900.—CARL BURCKHARD. "Profils géologiques transversaux de la Cordillera," Argentino-Chilienne *Anales del Museo de La Plata*, 1900; *Argentine-Chilian Boundaries in the Cordillera de los Andes, Argentine Evidence.* London, 1900. (F. P. M.)

Andes, Los, a state of Venezuela, formerly bounded on the N. by the states of Zulia and Lara, on the S. and E. by the state of Zamora, and on the W. by Colombia and a portion of Zamora. It had an area of 14,719 square miles, and a population estimated at 365,000. This area was recently divided into two states, Los Andes and Trujillo.

Andijan, a district town of Russian Turkestan, province of Ferghana, terminus for a time of the Transcaspian and Turkestan railway, lying 73 miles E.N.E. of Kokand on the left bank of the upper Syr-daria; altitude 1510 feet. It was formerly the residence of the Khans of Kokand, and is described as one of the most pleasant cities of Ferghana, on account of its beautiful gardens and large park situated in the midst of the town. A canal derived from the Syr waters these gardens, as well as the fields round the town. The cotton-tree being much grown in the district, Andijan is a centre for the trade in raw cotton, and has moreover nearly twenty factories for cotton cleaning, and several important firms. Andijan merchants, with their goods, are met with all over Central Asia. Population (1897), 46,680.

Andorra, or ANDORRE, a small neutral, autonomous, semi-independent state, with an area of 191 square miles, situated chiefly on the peninsular side of the Pyrenean chain. Its population, according to some estimates in 1887, was between 6000 and 12,000, but no trustworthy census exists. Its six parishes are subdivided into fifty-two pueblos or hamlets. The Andorrans are fond of the chase and of fishing in their streams. The more well-to-do classes now talk French fluently, and get their children educated in France. During the coldest winter months their communications are much easier with Spain than through the snow-clad passes leading into the Ariège. The local industries are of the most primitive kind, merely domestic, as in the Middle Ages. Lack of capital, of coal, and of good means of communication, prevents the inhabitants from making use of the iron and lead mines that abound in their mountains. They rear flocks of sheep, goats, cattle, and some pigs. The only roads are bridle-paths, and one municipal road by the Balire Valley, connecting Andorra with the highroad to Seo de Urgel and Tarruga. There is a scheme for extending a branch of the projected Noguera-Pallaresa railway to Seo de Urgel, close to Andorra. The climate is cold in general, and bitterly so in winter. There are some sheltered spots on the southern side of the Pyrenean chain, called Solanas, where the climate is milder, and there the soil is better cultivated, producing some fruit and agricultural products for a small export trade. Milk, butter, hams, skins, and wool are sent to France. The French *viguier* is taken from the French department of Ariège and appointed for life, but the *viguier* of the bishop must be an Andorran, holding office for three years and re-eligible. There are notaries and clerks, auditors for each parish elected by the heads of families, police agents and bailiffs, chosen and sworn in, like all the above officers, by the council general. The archives are mostly kept in the "house of the valley" in the capital, Andorra Vicilla, a struggling village of 600 inhabitants. This Government house has no merit beyond the fact that in it the council general meets and has a chapel, and in it the aldermen, *viguiers*, and judge of appeal administer justice and assemble for all purposes of administration. Two magistrates, styled *rahanadores*, are appointed by the council general to see that *viguiers* and judges preserve the customs and privileges of Andorra. The parishes have a permanent patrol of six armed men, besides the militia. Spain and the bishop of Urgel are very jealous of French encroachments, and claim to have a better right to annex the little state some day. In the meanwhile it continues to pay each of the "coprincipes" £40 a year, levied by a tax on pastures.

BERTHET. *Le val d'Andorre.* Paris, 1879.—MORAS. *Coutumes du pays d'Andorre.* 1882.—BAUDON DE MOUY. *Origines historiques de la question d'Andorre.* 1885.—VUILLIER. *Le val d'Andorre. The Valley of Andorre.* Riverside Press, Cambridge, with good map.

(A. E. H.)

Andover, a municipal borough and railway station, in the Andover parliamentary division of Hampshire, England, on the Anton, 12 miles N.W. by N. of Winchester. In 1889 a recreation ground was opened. In 1891 the waterworks were acquired by the corporation. Area of borough (a parish), 8662 acres; population (1881), 5653; (1891), 5852; (1901), 6000.

Andover, a town of Essex county in north-eastern Massachusetts, U.S.A., having an area of 33 square miles. It is situated on the south bank of the Merrimac, where the surface of the country is broken by small Glacial hills. The Theological Seminary here had in 1898 eight instructors and 41 students, and Phillips Academy had a faculty of twenty professors and was attended by over 400 students. Population (1880), 5169; (1890), 6142; (1900), 6813.

Andovoranto. See MADAGASCAR.

Andrassy, Julius, COUNT (1823-1890), Hungarian statesman, was born at Zemplin in the north-east of Hungary, 18th March 1823. His father, Count Charles (the representative of a family which had been settled in Hungary about 250 years), was a man of considerable literary and scientific attainments, and was therefore (as were all who cared for the prosperity of the country) a member of the national and Liberal opposition to the deadening government of the Austrian bureaucracy. Julius and his elder brother Emmanuel were therefore, from their earliest years, brought up to believe in the excellence of political liberty, and they were enabled by travelling to become acquainted with countries which enjoyed the free exercise of those institutions which the government of Metternich refused to Hungary. His political master was Count Szechenyi, who has been called the greatest of the Hungarians. The two brothers were elected in 1847 members of the Hungarian Diet; they joined the Opposition, which was led by Louis Batthyany, Deak, and Kossuth. Andrassy soon distinguished himself by his speeches; he was one of those who first claimed to use Magyar. He had a charm of manner and gallantry which would have made him a favourite anywhere, and completely won the hearts of the susceptible Hungarians. As the differences between the aristocratic party and Kossuth became serious, Andrassy was on the side of Kossuth; he supported him through all the stormy events of 1848, and he accepted the post of prefect of the county of Zemplin in order to carry out the internal reforms which the democratic party desired; he paid special attention to the organization of the militia. In the civil war of 1848 against the Croatians he took part at the head of the corps he had organized, and was present at the battle of Schwechat, when the Hungarians crossed the frontier and attacked the imperial troops on Austrian soil. He continued his association with the Government of national independence, and in 1849, when the interference of Russia became imminent, he went on a mission to Constantinople to ask for the aid of the Turks. In this he failed, but the sultan promised to protect Hungarian refugees, a promise which was honourably kept, and which the Hungarians have not forgotten. Andrassy escaped the fate of many of his colleagues by flying from the country, but he was condemned to death under martial law and hanged in effigy. He spent the next years of exile in France and England, and acquired a very thorough knowledge of the customs and institutions of these countries; like so many of his countrymen he was an excellent linguist. He was pardoned by the emperor in 1856; on his return to Hungary he joined the party of Deak, who claimed the independence of the country, but hoped to attain it by reconciliation with the house of Hapsburg, a policy which was bitterly opposed by Kossuth and his followers. He sat in the Diet of 1861, but refused to recognize it as a substitute for an independent parliament, and during the following years he was very active in gaining support to the principles of the Moderates. His opportunity came in 1866. He took a leading part in the negotiations which lead to the establishment of the "Ausgleich"; he was greatly instrumental in winning the confidence of the emperor and empress, and is said to have suggested the peculiar form taken by the Common Parliament or "Delegations." Deak was offered the post of minister-president of Hungary under the new constitution, but refused to take office; he suggested the name of Andrassy, who, he said, had been "sent by Providence." There was no one who could rival Andrassy's claims to be the first national Hungarian minister. As an old revolutionary he could command the adhesion of his former companions in exile; his birth and his early connexions won for him the support of the Liberal aristocracy, and he had the confidence of the emperor. He held this office for over four years, and quickly made political liberty and constitutional Government a reality, introducing full freedom of the press and of public meetings, granting political freedom to the Jews, and establishing the national militia or Honved, in which he took great personal interest. He exercised considerable influence on the foreign policy of the empire, and helped to keep in check the anti-German influences at Vienna. In 1870 he threw his weight decisively on the side of a public declaration of neutrality. In 1871 he was called to Vienna to use his influence in order to prevent the emperor accepting the federalistic scheme of Hohenwart. Andrassy represented that it would destroy the organization of the dual monarchy, and offered his resignation if it was carried out. The result of the crisis was that Hohenwart was dismissed, and Andrassy received the portfolio for foreign affairs for Austria-Hungary after the fall of Beust. The most important achievement of his policy in the new post was the establishment of a close understanding with Germany. The beginnings of this had been laid by the friendly relations which Bismarck had already established with the Hungarians. This led also to a better understanding with Russia, and Andrassy was much attacked in Hungary for his Russophile policy. He succeeded, however, in averting a war with Russia, which might easily have arisen out of the Balkan complications; by the "Andrassy Note" of 1876 he attempted to settle these by agreement with Russia. The summoning of a European congress to discuss the terms of peace imposed on Turkey by Russia was to a great extent owing to his initiative, and he brought it about that the administration of Bosnia and Herzegovina should be offered to Austria-Hungary. His policy in this was strongly attacked at home, both by the Hungarians and Germans, and the discontent was increased by the difficulties with which the occupation of the provinces was attended; he had failed to anticipate the opposition with which the Austrian troops were met. It was partly this discontent which led him in the summer of 1879 to offer his resignation, a step which has also been attributed to private reasons; he was, moreover, dissatisfied that he was unable to have some internal reforms carried in Hungary. It is probable that he did not expect his resignation to be accepted; or if it was, he undoubtedly hoped soon to return to office. His position as the first of living statesmen in the dual monarchy was so assured that he might well believe he was indispensable. His resignation was, however, accepted. Before he left office, he completed the work he had already begun by arranging with Bismarck a formal alliance of Germany and Austria-Hungary for mutual defence against Russia. By this he had placed the European position of his country on a secure basis. The best proof of the wisdom of his policy is that it has been continued by all his successors.

Andrassy lived till 1890; he was never again offered office; he could have forced his way back to power had he chosen to use his great popularity for this purpose; but, with a magnanimity which is not too common, when he spoke in the parliament it was to help and support his successors; his criticisms he reserved for private intercourse. He died 18th February 1890. Andrassy is undoubtedly one of the most interesting figures of recent history. It has often been said of him that he cared more for the appearance than the reality; he thought too much of outward effect. He had little patience for the details and routine of departmental work, and was intolerant of slowness and stupidity. He had, however, a quick power of seizing the essential factors in a situation; his mind was eminently sober and practical; he saved his country from the dangers into which it would have fallen had full freedom been given to the ideals of Kossuth and his followers, or to the anti-Russian passions which were so strong. He is identified with two great political achievements, the system of dualism and the alliance with Germany; both have justified themselves by the test of experience. More than this, it is largely due to his personal influence that from the beginning it was made apparent that in the partnership between Austria and Hungary the latter was the stronger member; and so long as he was foreign minister he secured for the dual monarchy a position in European affairs which it had not had for many years.

(J. W. He.)

Andrews, Thomas (1813-1885), Irish chemist and physicist, was born on 19th December 1813 at Belfast, where his father was a linen merchant. After attending the Belfast Academy and also the Academical Institution, he went to Glasgow to study chemistry under Professor Thomas Thomson, and thence migrated to Trinity College, Dublin, where he gained distinction in classics as well as in science. He next spent some time in Paris, in the laboratory of the famous chemist Dumas, and finally, having graduated as M.D. at Edinburgh in 1835, settled down to a successful medical practice in his native place. Ten years later he was appointed vice-president of the newly-established Queen's College, Belfast, and professor of chemistry, and these two offices he held till 1879, when failing health compelled his retirement. He died 26th November 1885. Andrews first became known as a scientific investigator by his work on the heat developed in chemical actions, the Royal Society awarding him a Royal medal in 1844. Another important research was devoted to proving that ozone is a definite body, an allotropic form of oxygen, containing three atoms in the molecule instead of two, as is the case with the ordinary gas. But the work on which his reputation mainly rests and which best displayed his skill and resourcefulness in experiment was concerned with the liquefaction of gases. He carried out a very complete inquiry into the laws expressing the relations of pressure, temperature, and volume in carbonic acid gas, in particular establishing the conceptions of critical temperature and critical pressure, and showing that the gas passes from the gaseous to the liquid state without any breach of continuity.

Angers, chief town of department Maine-et-Loire, France, and an important centre for several railway lines, 188 miles S.W. of Paris. There is a Hôtel-Dieu, now a civil and military hospital; but it is the Hôpital-Ste-Marie, a large modern building with 1500 beds, that takes the place of the ancient Hôtel-Dieu or Hospice St Jean, said to have been founded by Henry II., which is now occupied by the archæological museum. The public library, contained in a fine edifice dating from the 15th century, has been much enlarged. Palæontological and antiquarian museums are also housed in ancient buildings of considerable interest. A 12th-century clock tower is part of the ancient abbey of St Aubin. The Palais de Justice is a modern building in the Champ de Mars. Amongst educational institutions may be noted a national school of arts and handicrafts, a free school of design, and a school of pharmacy. Manufactures of umbrellas, boots and shoes, iron goods, cables, and copper ware, have become important. In the vicinity are many nursery gardens. Large stock fairs are held, and there is considerable trade in hemp, flax, and other agricultural produce. Electric tramways connect with the suburbs. Population (1881), 58,571; (1891), 62,391; (1896), 69,484, (comm.) 71,119; (1901), 83,966.

Angiosperms.—The term "Angiosperm" (ἀγγεῖον, receptacle, and σπέρμα, seed) was coined in the form Angiospermæ by Paul Hermann in 1690, as the name of that one of his primary divisions of the Plant Kingdom which included flowering plants possessing seeds enclosed in capsules, in contradistinction to his Gymnospermæ or flowering plants with achenial or schizocarpic fruits—the whole fruit or each of its pieces being here regarded as a seed and naked. The term and its antonym were maintained by Linnæus with the same sense, but with restricted application, in the names of the orders of his class Didynamia. Its use with any approach to its modern scope only became possible after Robert Brown had established, in 1825, the existence of truly naked seeds in the Cycadeæ and Coniferæ entitling them to be correctly called Gymnosperms. From that time onwards, so long as these Gymnosperms were, as was usual, reckoned as dicotyledonous flowering plants, the term Angiosperm was used antithetically by botanical writers, but with varying limitation, as a group-name for other dicotyledonous plants. The advent in 1851 of Hofmeister's brilliant discovery of the changes proceeding in the embryo-sac of flowering plants, and his determination of the correct relationships of these with the Cryptogamia, fixed the true position of Gymnosperms as a class distinct from Dicotyledones, and the term Angiosperm then gradually came to be accepted as the suitable designation for the whole of the flowering plants other than Gymnosperms, and as including therefore the classes of Dicotyledones and Monocotyledones. This is the sense in which the term is nowadays received and in which it is used here.

The Angiosperms and the Gymnosperms together compose the group of Spermophytes — also named Phanerogams—Seed Plants or Flowering Plants. The expressions seed plant and flowering plant convey the essential character of the group. The seed is the product of the flower—the conception of the flower implies that of the seed. In no other group of plants is there a seed or a flower, although the terms are sometimes loosely used with reference to plants of lower organization. The trend of the evolution of the plant kingdom has been in the direction of the establishment of a vegetation of fixed habit and adapted to the vicissitudes of a life on land, and the Angiosperms are the highest expression of this evolution and constitute the dominant vegetation of the earth's surface at the present epoch. There is no land-area from the poles to the equator, where plant-life is possible, upon which Angiosperms may not be found. They occur also abundantly in the shallows of rivers and fresh-water lakes, and in less number in salt lakes and in the sea; such aquatic Angiosperms are not, however, primitive forms, but are derived from immediate land-ancestors. The varying climatic or environmental conditions to which Angiosperms may be exposed in their wide distribution, including those of the soil, *edaphic*, those of the atmosphere, *epedaphic*, and those of water, *aquatic*, find their response, within the limits of phylogeny, in the external form and internal structure exhibited by the plants. Angiosperms of a tropical forest, for example, are manifestly of different form from those of an alpine region, or again Angiosperms growing submerged in a lake have features readily separating them from plants of a desert plain; the differences are not confined to points of their outward form, but obtain throughout their internal structure. The study of the relationships of Angiosperms, as well as of other plants, to their environment has in recent years become a fascinating and productive field of botanical work to which has been given the designation "Œcology" (sometimes written "Ecology"). From the standpoint of their relation to environment Angiosperms fall into the three main categories of *Geophytes*, *Aerophytes*, *Hydrophytes*. Geophytes are plants adapted to a land-life with fixation in the soil, and therefore they are subject to the influence of both edaphic and epedaphic factors of environment. Aerophytes are adapted to a land-life with fixation upon another plant, and are therefore subject to the influence of epedaphic factors of environment only. Hydrophytes, being adapted to life in water, whether free or fixed, are subject to the influence of the aquatic environment alone. These categories are not altogether sharply distinguishable, and many plants have the capacity of dual adaptation; *e.g.*, Batrachian Ranunculi may be either hydrophilous or geophilous; *Ficus bengalensis* as a juvenile is aerophilous, but geophilous when adult.

Œcology.

I. *Geophytes.*—Geophytes overwhelmingly predominate in the world, and from them we derive our concept of the typical Angiosperm, which for the performance of its life-work has two series of vegetative organs severally adapted to the media—soil and atmosphere—in which they are exposed. They are the root or descending system and the shoot or ascending system composed of stem and leaf. To the root belongs the special work of fixing the plant in the soil and of absorbing material for food in a liquid state. To the shoot is assigned the special task of taking in material for food in a gaseous form from the atmosphere and of absorbing the radiant energy of the sun.

Vegetative organization.

The primary root formed at the base of the embryo pierces the soil as a main radially-constructed orthotropous root, from which lateral endogenetic plagiotropous rootlets branching like the mother proceed. Roots elongate by means of an intercalary pluricellular growing point covered by a protecting root-cap, and bear over a short distance close behind the point a covering of short-lived active hairs, the agents alike of fixing and absorbing.

The depth to which the root-system of Angiosperms penetrates the soil is apparently conditioned by the needs of respiration, and even in plants with highest shoot-development in temperate regions is not over 4 feet, save in exceptional conditions. The growth in length of the main root is therefore soon arrested. The horizontal extension of the lateral roots is practically indefinite. The elongation and persistence of the primary root is a characteristic feature of dicotyledonous Angiosperms, and is in marked contrast with what is commonly found in Monocotyledones and in Pteridophytes, and is evidently correlated with their more elaborate development of shoot. Where the primary root elongates in Monocotyledones it rarely persists for any time, even in cases where there is a considerable bulk in the shoot-system; the root-system is then provided by adventitious roots from the stem.

The primary shoot-axis has two portions—the hypocotyl with its cotyledon or cotyledons, the portion first formed in the embryo, and the epicotyl, which in the embryo exists as the plumular bud. The latter elongates as a radial orthotropous axis, with a terminal pluricellular growing point of indefinite growth covered more or less by incipient leaves, both scale-leaves and foliage-leaves, to form a leaf-bud, and these arise from nodal points as exogenetic outgrowths, commonly dorsiventral and of limited intercalary basipetal growth. Branches like the parents, but plagiotropous and often dorsiventral, arise exogenetically in the axils of the leaves. The leaves (as also their axillary branch) have a definite position—spiral or cyclic—upon the stem.

The degree to which the shoot is developed and its duration above ground have given origin to the popular designations *herb*, *shrub*, *tree*, and these terms, although not capable of scientific definition, for the forms they indicate pass one into the other, are nevertheless landmarks in outward form development—*growth-forms*—in relation to climatic factors, and are therefore of œcological value. To them may be added *liane*, as the designation of a subsidiary form of wide-spread occurrence. A herb being a plant—annual or perennial—which loses and renews its shoot-growth from year to year, and often also loses and renews its root-system, does not rise to any great height above the soil. It is therefore not greatly exposed to air-currents, and it may for a considerable portion of the year be subterranean and consequently under more equable conditions than when above ground; it dwells in a moist stratum of the

Growth-forms.

atmosphere and may readily be overshadowed by other plants. Herbaceous growth makes a carpet of vegetation upon all areas of the earth's surface, but is essentially a feature of temperate regions. Trees, on the other hand, have a persistent aërial trunk with copious shoots, and they are therefore woody and may be evergreen or have deciduous leaves. Their growth brings them into atmospheric strata drier than those near the soil, where they are more exposed during the whole year to air currents and to every change of temperature, and where they are not liable to be overshadowed except by their fellows. Tree-growth then may be said to affect moist sheltered areas; cold dry wind-swept regions, for instance the polar and alpine, are treeless. As the intermediate form between herbs and trees the shrub merges into both, and is found along with or replacing them in all areas. The liane may partake of the character of each of the preceding forms, but its special feature is that rooting in the soil it makes use of the support of other plants to secure an extension and exposure in the atmosphere, and in this way may attain a length of many yards. To this end it may adopt the habit of a twining stem, or it may climb by means of modifications of its organs such as prickles, hooks, leaf-tendrils of various degrees of conversion, and stem-tendrils of kinds. Liane-growth is found in all areas of vegetation, except, and for obvious reasons, in polar and alpine regions, but it reaches its maximum development in the tropics where woody twining stems and stem-tendrils are specially developed.

Colonial organization.

A fundamental character of Angiosperms, as indeed it is of all plants excepting the unicellular Protophytes, but one which is too often lost sight of in the study of their economy, is their colonial organization. The living plurinucleated protoplasm of the plant-body is spread over the skeletal support furnished by the cells of the root and shoot, and in the more highly differentiated forms occupies but a small area of the whole body of the plant. Each living cell encloses an energid (a portion of the protoplasm dominated by a nucleus) which is connected by protoplasmic threads piercing the cell-membrane with the adjacent energids, and thus the protoplasmic body forms one continuous whole in the plant. (See CYTOLOGY.) According to their position in the organism, the primary cells become devoted to the formation of special tissues building up the organs required for the discharge of the several life-functions of the plant, but nevertheless each living cell must be regarded as a potential protophyte, whilst its actual destiny is determined by its relations to the other cells. This colonial organization of the Angiosperm enables it to have growth prolonged in one direction whilst this is arrested in another, to throw off effete and old parts of its body without mutilation, and to renew or replace them as required; all tissues which pass out of the sphere of active life are not, however, thrown off, for it is a marked feature of Angiosperms that such tissues, and many excreta also, may be enclosed by the living ones and remain unchanged so long as they are unexposed to the putrefactive influences of the atmosphere. The fixed organism as a whole is endowed with what we may term potential immortality—a character in sharp contrast with the relatively short period of life of the motile individuals of the higher members of the animal kingdom. We have but little accurate information bearing upon the actual longevity of Angiosperms by which to judge whether their theoretical expectation of life may come to realization. Perennating herbs and under shrubs probably approach most nearly to its fulfilment. Shrubs and trees expose themselves by their aërial growth to many accidents which militate against great length of life; nevertheless there are authentic instances of trees, for instance *Ficus religiosa*, whose years must be counted by thousands. On the other hand many Angiosperms are pronouncedly short-lived, passing through birth, vegetation, reproduction, and death within a few months.

Duration of life.

For an account of the internal organization of Angiosperms, see ANATOMY OF PLANTS. The primary disposition of the permanent tissues in an Angiosperm is determined by the necessity of providing an ample mechanism for carrying water from the absorbing ends of the roots to the other seat of absorption of food-material in the leaves, and to all growing points for the maintenance of turgidity; the carrying system therefore dominates the anatomy, its position and form in each organ having relation to the strain to which the organ is liable. In Dicotyledones the monostelic system admits of an indefinite extension of the area of the carrying system to keep pace with the growth and extension of the often ample perennating shoot-system, and this has contributed largely to the establishment of the group as the dominant vegetation of our day. The polystelic condition so common in Pteridophytes is occasionally found, but only in forms which are not progressive. The absence of this capacity of increase of the carrying system in Monocotyledones is probably one of the factors which have led to their insignificant development as tree-forms as compared with Dicotyledones.

Environment and configuration.

Though the geophyte responds in some degree in the configuration of its vegetative organs to all the physical and chemical conditions of its environment, we have as yet but little certain knowledge of the effect to be ascribed to some of these or of the manner of their operation. Nor are we able as yet, even in the case of those factors of which we know most, to determine clearly in every instance how far their influence is controlled by intrinsic causes, expressed for instance in correlation, or is modified in combined action with other factors. We know that the direction and disposition of the parts of the root and shoot are directly influenced by the stimulus of gravity, and also that radial and dorsiventral constructions are often conditioned by light which also may induce anisophylly and the flattening of organs; light also may be a direct cause in provoking a difference in form between the juvenile and adult foliage, with the result that the organs concerned in carbon-dioxide-assimilation and in the absorption of energy are exposed in the most favourable manner to illumination. The direct influence of light in formation of chlorophyll is well known. Configuration appears to be but little directly influenced by temperature excepting perhaps by extreme cold, and we can seldom say by consideration of its outside whether a plant inhabits a warm or a cold climate, notwithstanding the paramount influence temperature exerts in the distribution of specific forms. The most influential environmental factor in relation to form and structure is unquestionably water. Water-carriage within the plant determines its anatomy, and the safeguarding of the water-supply alike at its intake in the root-system and at its outgo by transpiration and by transudation in the shoot, is a prime concern of the vegetative organization of geophytes, and is modified in relation to the amount of water available for the functional purposes of the plant. This does not always correspond with the actual amount of water in the physical environment, and a plant may be in a condition of physiological drought in the midst of an abundance of water. When there is a risk of physiological drought—as in areas where the absorption of water from the soil is hindered, *e.g.*, by a scant amount of water, by too much dissolved salt, by humus, or by low temperature, as well as where transpiration and transudation are facilitated, *e.g.*, by the dryness or high temperature of the atmosphere, by low barometric pressure, and by intense light—the plant responds and means are developed to promote the intake and check the outgo. For the former there may be an increase of the whole root-system and of the absorbing

Xerophily.

hairs, as well as of the carrying vasa; for the latter there is great variety of method in relation to other œcological factors. There may be a reduction in the amount of the transpiration-surface by the shortening and thickening of the stem and the foliage-leaves, or even by the suppression of the latter (*aphylly*) leading to stem-assimilation, the development of *cladodes*, and the production of non-transpiring *thorns*, while by the formation of vertical leaves and *phyllodes* the effect of insolation is restricted. Obstacles to transpiration are created by increase in thickness and in cutin-content of the outer wall of the epidermal cells, by the sinking of the stomata, by the development of a covering of hairs, or in compound leaves by collapsing movements. In many cases water-storage of kinds is provided, from which loss may be supplied and succulence of stem (*chylocauly*) or of leaf (*chylophylly*) is developed. An increase in the sclerenchyma-tissue of stem (*sclerocauly*) or of leaf (*sclerophylly*) and an elongation of the palisade-cells of the leaf are also accompaniments of this adaptation. Such adaptations are termed *xerophilous*, and plants exhibiting them are *Xerophytes*. The conditions which induce the xerophilous structure are conspicuously and most typically found in desert areas, but they also, in varying degree, surround plants growing on the surface of rocks (*Lithophytes*), in rock-fissures (*Chasmophytes*), on sandy porous ground (*Psammophytes*), on the shore (*Halophytes*), on peat-moors (*Ericophytes*), and elsewhere. In marked contrast with xerophilous configuration and structure are the ***hygrophilous*** features which characterize *Hygrophytes* or plants which are not, or only rarely and temporarily, liable to any danger from deficiency of water-supply. Here the presence of a feeble absorptive root-system and an extended surface of the shoot for transpiration and transudation are the outstanding points. The latter is exhibited in the elongated stems which do not bear thorns, although prickles are not uncommon, the large surface and the thinness of the leaves which frequently have "dropper tips" or other arrangements for quickly throwing off water, the large air canals, abundant and exposed stomata, and many hydathodes. The risk to hygrophytes lies in their exposure to strong insolation or to prolonged air currents, and these may cause flagging of the organs; but loss from such causes is soon recovered, and may be provided against by water-storage in or near the epidermis. Hygrophytes occur in moist areas, and are particularly abundant in the tropics. The degree to which xerophilous or hygrophilous construction is developed varies, and some plants exhibit a seasonal alternation of these characters, and have been therefore termed *Tropophytes*. In the wet or warm season they are hygrophilous, in the dry or cold season they are xerophilous. The feature distinguishing them is the casting of the greater portion of their transpiration-surface at the beginning of the period when there is a risk of physiological drought, by the dying down of the annual shoots of herbs, and by leaf-fall and branch-fall of shrubs and trees. That this is a preparation for physiological drought every gardener may see when he transplants such an evergreen as a holly. Deciduous-leaved trees and shrubs of temperate regions have hygrophilous foliage, but the stems are xerophilous, being protected by cork, and the buds are enveloped in scales, resin, and so forth. Evergreens of temperate regions have xerophilous leaves, their young leaves alone showing hygrophilous characters. Any one of the growth-forms—herb, shrub, tree, liane—may exhibit features of xerophily, hygrophily, or tropophily, and their adaptations upon these lines determine the physiognomy of vegetation within the thermal zones of the globe.

Hygrophily.

Tropophily.

Gamogenetic reproduction.

Angiosperms (like Gymnosperms) are heterosporous, as are some of the Pteridophytes, but unlike these they do not spread by the scattering of the megaspores. On the contrary the megasporangium remains persistently closed and attached to the sporiferous plant, whilst the megaspore which it contains (for there is commonly but one) germinates within it and produces the structures which are the homologues of the female gametophyte of the Pteridophytes with its female gametes. Nor does this intrasporal development cease here. Conjugation of the male and female gametes takes place within the spore, as does also the subsequent segmentation of the resulting zygote, and its further development through the stage of pro-embryo to the formation of the perfect embryo of a sporophyte. There is thus produced in the position of the original megasporangium a body consisting, in its simplest form, of a coat to the outside composed of the wall of the megasporangium and of the wall of the megaspore, both of them much altered, and within of an embryo sporophyte. This body is the *seed*. For a longer or shorter time it remains attached to the sporiferous plant, and its ultimate separation provides for the spread of the angiospermous plant. It is this character—of a closed megasporangium and the development of seed—which separates sharply the Angiosperms and the Gymnosperms from all other classes in the plant kingdom, and which makes so apt their designation in one group—the Spermophytes. The exigencies of their adaptation as a land-vegetation have made the development of sexual cells in them not a first charge upon an independent or nearly independent organism arising from a spore, as is the case in the Pteridophytes, but these appear as late products on a vast vegetative structure through which the outcome of their coalescence, the embryo, can be nourished for a time, and from which it is subsequently shed, well protected in the seed-coat to withstand climatic vicissitudes yet ready to take its position as a new plant whenever environmental conditions permit. The risk of failure of sexual reproduction through non-propinquity of the essential energids overhangs the higher Pteridophytes at two stages of their life history, and frequent actual failure may have hastened their retrogression as a dominant vegetative type; there is first of all that of non-association on the same nidus of the fortuitously distributed microspores and megaspores, and second that of a missing of coalescence of the male and female gametes, inasmuch as the act involves a sufficiency of moisture for germination, and through which the male gamete must actively move to its goal. In the Angiosperms this risk is, to their advantage, reduced to a single one, that of a mishap in pollination, for the avoidance of which have been developed the elaborate contrivances which make up the flower of to-day.

The flower.

The part of the Angiosperm through which the formation of seed takes place is the flower. This is a shoot, bearing sporangia which contain spores, both sporangia and spores being concerned in the production of the seed. Function as well as structure is therefore involved in the conception of flower. Sporangiferous shoots resembling those of some Angiosperms are found outside the Spermophytes in, for example, *Selaginella*, and they have the structural features of flower, but they do not form seed, and are therefore not flower. Nowhere, except in the Gymnosperms and Angiosperms, do we find such sporangiferous shoots implicated in the physiological processes which result in the seed. The *microsporangia* (*pollen-sacs*) containing *microspores* (*pollen-grains*) and the *megasporangia* (*ovules*) containing *megaspores* (*embryo-sacs*) are enclosed in leaves, respectively, the *microsporophylls* (*stamens*) and the *megasporophylls* (*carpels*) attached to the *axis* (*torus*) of the flower.

These leaves may be together on the same torus (*hermaphrodite flower*), or on separate ones (*unisexual flower*). The stamen has typically a petiolar portion (*filament*), and a laminar portion (*anther*), and within the latter the pollen-sacs, of which there are commonly four, each containing many pollen-grains, are embedded. The carpel is a leaf folded upon itself to form an ovary investing the ovules. These arise, each with its embryo-sac, from the tissue of the placenta placed either upon the carpel (*foliar*) or upon the torus (*axial*) which projects into the cavity of the ovary; in epigynous flowers the torus shares more or less in the formation of the wall of the cavity. The apex of the carpel is more or less prolonged as the *style* upon which a special papillar or hairy secreting germinating surface of varying extent, the *stigma*, is developed. Upon this stigmatic surface the pollen-grains which are carried to it (*pollination*) from their mother pollen-sacs, continue their germination, and then through the pollen-tube the male gametes they produce are conveyed to the female gamete enclosed in the megaspore. The anther-wall enclosing the pollen-sacs is commonly no more than an epidermis in the greater part of its extent, and usually contains parasolar colouring substances which protect the developing pollen-grains. It forms with the walls of the pollen-sacs a hygroscopic mechanism, through which it is ruptured in definite areas for the escape of the pollen-grains at the period when these are mature. The ovarian wall is green, or possesses at least some chlorophyll and frequently meristem, and thereby is fitted for the subsequent developments through which it becomes the fruit, enclosing for a longer or shorter period the seeds into which the ovules develop. The number, form, size, colour, cohesion, adhesion, branching of the sporophylls give manifold variety of flower-structure, but the features in the sporophylls which are of significance from the phyletic standpoint, and by which the Angiosperms as a whole are distinguished from the Gymnosperms are—(1) the greater protection afforded to the ovules by their enclosure within the ovary of the carpel, and (in the higher forms) within the torus itself, and to the pollen-sacs by their investment in the anther; and (2) the provision of a carpellary germinating surface in the stigma for the pollen-grains, with the correlated specialization of the stamen into filament and anther.

Flower-envelopes.

The flower may be constituted by the sporangiferous portion alone, and the sporophylls are sometimes spoken of as its essential organs. But the parts which give conspicuousness to most flowers, and which are indeed in the popular and gardening sense of the term "flower" the important ones, are the flower-envelopes—*calyx* of *sepals* and *corolla* of *petals*. One of these only may be present. Their presence is a mark of angiospermous structure, the flower in Gymnosperms having only obscure homologues. Sepals are typically green, and share therefore in the assimilation-work of the plant, no doubt aiding in meeting the very great demands made upon the plant-energy by spore-formation in the flower and its consequences. They are frequently persistent and active in this way during the whole period of maturation of the seed. Whilst in the earlier stages of the flower-development they serve as protecting structures to the parts within, they also when persistent provide a protection, or it may be an aid in dissemination, to the fruit or seed. The brilliant colours of the flower are most frequently located in the petals, although the sepals and sporophylls and adjacent parts are also often coloured. With the calyx the corolla serves as a protection to the young sporophylls, especially from wet. Once expanded the petals may remain so until they are shed, as they usually are after pollination has been effected, or they may with the calyx close over the sporophylls and open again, more than once, in response to various external stimuli. Their colours, primarily parasolar, appear to be attractive to birds and insects, and these by their visits aid in the pollination of the flower, and have been agents in the intensification of the colours through selection. The leaves of the flower-envelopes vary in every way more than do the sporophylls, and show frequently extreme specialization in their forms, which in many cases appear to be correlated with the visits of birds and insects. Another accessory feature present in many flowers, and especially in those with colour, is the secretion of honey, with the associated odour, from nectaries. These nectaries, often termed *nuptial*, to distinguish them from similar ones which occur upon parts of the plant away from the flower (*extranuptial*), may arise upon the torus independently of the flower-leaves, or may be produced by any one of these leaves. The secretion is usually discharged from the nectaries, but in some cases is retained, and can only be secured by puncture. Odour appears to be the most potent attraction to birds and insects possessed by flowers.

Nectaries.

The flower has primarily a radial construction with a spiral or cyclic (or these combined) disposition of the flower-leaves; the terminal flower of an inflorescence is always radial. Lateral flowers may be radial, but are frequently dorsiventral, a construction which, primarily an adaptation to physical needs, has been intensified by insect-agency. The relative number and positions of the different kinds of flower-leaves are characteristic features, and in lateral flowers have a definite relationship to the mother-axis of the flower, as well as to the prophylls—the common trimery of Monocotyledones showing typically an anterior sepal in relation to the one posterior prophyll, whilst in the pentamery and dimery of Dicotyledones there is usually a posterior sepal with a pair of lateral prophylls. All these relationships (and they are of great variety) of the flower-leaves are of considerable value in the estimation of the genetic relationships of the families of Angiosperms. The formation of flower concludes the growth in length of the axis to which it belongs. If this be the primary, or relatively primary axis the plant is *monaxial;* the majority of plants are, however, *pluriaxial*, the flowers belonging to axes of higher degree. In both cases there is a tendency to aggregation of the flowers in inflorescences, whereby small flowers become more conspicuous and the function of the flower is promoted. The position of the sporophylls at the end of their axis gives them prominence, and the whole arrangement of flower, whether solitary or in inflorescences, at the extremity of shoots, and its projection, as is common, beyond the vegetative organs is of obvious advantage. In contrast with the usual relation, *cauliflorous* trees are not uncommon in the tropics. In them the flowers which have often somewhat fleshy flower-envelopes, and are always odorous, appear singly or in groups upon small short-lived twigs, which develop from persistent axillary buds, or are found issuing from "latent eyes" in the bark. Their position close to the seat of reserve-food is evidently an economical one, and may have a relation to pollination, and their occurrence in tropical trees and absence from those of temperate regions may be made possible by the thinner bark developed upon trees in the tropics. The antagonism observable between vegetative and reproductive functions is well known, and environmental conditions such as physiological drought and low temperature, which are unfavourable to vegetative activity, are not so unfavourable to, and even favour, reproduction. Periodicity in flowering is most marked where there is seasonal growth, and flowering commonly concludes a vegetative period in which takes place an accumulation of energy sufficient to supply the demands made in the seed-formation, the exhausting nature of which is shown by the long intervals for recuperation, often a dozen years, between successive full crops in such trees as beech. When flower is produced before seasonal vegetative activity begins, a store of reserve-food from a preceding year is available for its formation. Where seasonal growth is not sharply marked, as in parts of the tropics, there may be continuance of flower during the whole year, but not from the same shoots. The action of light in intensifying the colour and odour of alpine flowers is well known.

Microsporangium.

The sporogenous tissue is formed within each of the four sporangia, two of which are in each lobe of the anther, though there may be two only, or there may be more. Each sporangium has the usual tapetum and wall-layers, and these are eventually more or less absorbed, as are also certain of the tissues of the anther itself betwixt adjacent sporangia, so that their cavities unite. In the ripe anther, therefore, the traces of the original sporangia are somewhat obliterated. The spores are produced in tetrads, each within a sporocyte, by two successive bipartitions of its energid. In monocotyledonous plants each partition is completed by formation of a cell-membrane around the daughter-energids, whilst in dicotyledonous plants the partition of the mother-energids into four daughter-energids is effected before these are invested by cell-membrane—a hastening of development observable also elsewhere. The spores when mature commonly become separated one from the other, but may remain united in tetrads, which may themselves remain coherent. Even when isolated the spores do not always form a dry powder, but may be entangled by connecting threads of the débris of the sporangial and antherine tissue. Of various shapes, the mature spores have the usual wall of two layers, here called the *exine* and *intine*. The exine, more or less cuticularized, may be smooth, but more frequently exhibits a pattern through local thickenings, and there are usually small areas where it is thin and less cuticularized, the so-called *germ-pores*, through which the intine, which is a delicate cellulosic membrane, will protrude in the later germination of the spore. All these conditions of shape, pattern, freedom, coherence of the spores, are of infinite variety; in this respect they markedly contrast with the spore-features in the Pteridophytes, and find their explanation in the work of pollination. Whilst still within the pollen-sac the spore reaches a stage of development at which its germination can begin. Its energid divides, but the daughter-energids are not of equal dimensions, and neither of them in Dicotyledones becomes invested by cell-membrane; in Monocotyledones this may be formed. One, the larger, has a purely nutritive destiny, and is termed therefore the *vegetative energid;* the other, smaller, is the mother of the male gametes, and is termed the *generative energid*. In many dicotyledonous plants this generative energid divides in the spore to form two daughter-energids, each of which is a functional male gamete, and the spore therefore within the pollen-sac contains three energids. In monocotyledonous plants this further division of the generative energid may be postponed to a later phase of germination. These changes within the pollen-grain present us with the reduced homologues of the male gametophyte and its products in the Pteridophytes, and the reduction is much greater than in Gymnosperms. The pollen-grain in this condition is ready for pollination, and unless this occurs no further change normally takes place in it, although if the pollen-grains within the anther be wetted, say by rain, one or more futile pollen-tubes may be sent out. It is to guard against this that so many protective arrangements to the pollen are provided in the flower.

Megasporangium.

The destiny of the ovule as the nursery of the embryo in Spermophytes imposes the necessity of a more elaborate construction than is found in megasporangia unconnected with seed-formation, and this finds expression in its envelopes and the water-carrying system and food-store they provide. The ovule arises as a cellular papilla upon the placenta, and as it gradually acquires its mature form, from atropous to anatropous, and with or without a conspicuous *funicle*, its *nucellus* becomes invested by one or two envelopes, the *integuments*, which, growing out from beneath its base, form, by their upward extension, a *micropyle* at its apex. The vascular bundle-system of the placenta is prolonged into the base of the nucellus, but future nucellar development precludes its further extension therein; it is therefore arrested expanding to a varying degree, or it spreads with often intricate ramifications in the integument—usually in the outer if there be two. These integuments are then ovular (sporangial) outgrowths which primarily construct the normal channel of entrance of the pollen-tube, and permit of the elaboration of the water-carrying system of the ovule, but, retaining more or less their meristematic character, they subsequently, when sharing in the formation of the seed-coat, alter their structure and may form *arils* of kinds. In holoparasites which form ovules the integument is often absent. In most gamopetalous Dicotyledones there is only one, but in Monocotyledones and most polypetalous Dicotyledones there are two. The significance of this is not apparent. That the integuments are structures of slight phyletic import is shown not only by their somewhat varied structure and points of origin, but by the fact that in some families, for instance, the Ranunculaceæ and the Rosaceæ, genera are unitegminous, whilst others are bitegminous. As the nucellus develops, spore-formation proceeds within it. The sporogenous tissue is usually a short sub-apical hypodermal axile row of cells, one of which becomes the megaspore or embryo-sac. There are in some cases several embryo-sacs which may develop, up to a certain point, when one takes the lead and the others are absorbed by it. The embryo-sac begins to enlarge at a very early period of the growth of the nucellus and elongates in the axis of this and towards its base, absorbing the nucellar tissue. It also enlarges laterally by the same method. As its enlargement proceeds, so do changes in its energid, which divides in the transverse plane of the sac. The daughter-energids recede to the respective poles of the elongated sac, and there each divides by two successive bipartitions to form a group of four. Of the basal polar group three invest themselves with cell-membrane and constitute the *antipodal cells* of the mature embryo-sac, the fourth moves upwards towards the equator of the sac. Of the apical polar group three remain at the apex, but do not invest themselves with cell-membrane, and constitute the so-called *egg-apparatus*, one of them larger than the others being the *female gamete* or *egg*, the others the *synergidæ* or *help-cells;* the fourth, which is the sister of the egg, moves downwards towards the equator of the sac, and meets the detached fourth member of the basal polar group, with which it sooner or later coalesces to form the *definite energid of the embryo-sac*. Viewing the embryo-sac as a megaspore, an obvious interpretation of these changes within it is that they are the consequence of its germination, and are therefore the homologues of the endospermic prothallus of Gymnosperms and of the female gametophyte in the Pteridophytes; this explanation has received very general acceptance. The antipodal cells would be cells of a reduced prothallus; of the three energids of the egg-apparatus, one alone is normally functional as the egg, but the synergidæ may, it has been said, function as eggs. The crux is, however, the interpretation of the definite energid, and its formation has been explained as a case of reinvigoration of a decadent vegetative organ by coalescence similar to what is frequently observed elsewhere in the plant kingdom, notably amongst the Fungi. It would be then an element of the prothallus. Other interpretations have traced a sexual act, and a conjugation of male and female gametes in the formation of the definite energid, or a concrescence of two female gametes. It is, however, unnecessary to discuss these, because recent researches have brought to notice altogether new facts in the history of the changes in the embryo-sac in fertilization, and to them reference will presently be made; these, though they do not clear up the difficulties of interpretation of the formation of the definite energid, must be taken as a starting-point in any explanation that may be advanced. The embryo-sac in most ovules has arrived at the stage of development above described when pollination is effected. But this is not always the case. The embryo-sac may not be formed, the ovule itself may hardly be visible when the pollen-grain reaches the style, and in these cases it is through the stimulus of the growth of the pollen-grain that the changes in the embryo-sac are initiated.

Pollination.

The pollen-grains escape from the anther by its rupture through differences in drying between its epidermal layer and the fibrous wall of the pollen-sacs within. As a rule the pollen-grains are simply exposed by this rupture, but in other cases the relations of the stamens and the flower-envelopes give rise to an explosive mechanism, brought into action either from the inside by the natural expansion of the flower, or by mechanical disturbance from without, by which the pollen-grains, which in such a case are always dry and powdery, are shot out to some distance from the flower. The destination of the pollen-grains is the stigmatic surface of the carpel, to which they cohere partly through the viscid secretion exuded from it, partly through entanglement amongst the stigmatic papillæ, and to this outgrowths of the exine may contribute. The proximity of the stamens and carpels in a hermaphrodite flower, and the fact of their ripening, as is common, at the same time, render possible the direct application of the pollen to the stigma either by contact of anther and stigma, by its falling from anther upon stigma, or in other ways, within the one flower. This is *self-pollination* and it takes place undoubtedly with frequency in nature, and may be said to be the *raison d'être* of the hermaphrodite flower. It is often called *self-fertilization* or *autogamy*, but in using these terms and other terms of similar form, and they are common, it must be remembered that pollination is only a spore-distribution, and a step on the way towards the accomplishment of the sexual act which is *fertilization*, and which indeed may not result after pollination. When the flowers are unisexual, whether on the same plant (*monœcism*) or on separate ones (*diœcism*), such facile pollination is precluded, and it must be effected by the conveyance of pollen from the stamens of one flower to the stigma of another. This is *cross-pollination*, often termed *cross-fertilization* or *allogamy*. Experiment has, however, shown that even in hermaphrodite flowers cross-pollination may be the more effective process in its ultimate result after fertilization has been effected, and that the progeny of a cross-pollinated hermaphrodite flower is often better than that of one self-pollinated. Cross-pollination is also frequently preferred even when the flower is hermaphrodite and self-pollination might be possible, for there are arrangements of different kinds which may either altogether prevent self-pollination or at least promote cross-pollination in the first instance. Thus the relative position of anthers and stigma and the form of the pollen may be such as to place a barrier to self-pollination (*hercogamy*), or the periods of rupture of anthers and of maturation of stigma may be different (*dichogamy*, either *protandrous* or *protogynous*). At the same time, in many hermaphrodite flowers which are normally cross-pollinated, self-pollination becomes possible before withering, and may take place should cross-pollination have failed. On the other hand, there are flowers which are so constructed as entirely to exclude the chance of cross-pollination, inasmuch as they do not open, and self-pollination is therefore a necessity (*cleistogamy*). The agencies by which cross-pollination is effected in Geophytes are wind and animals, and their flowers have been classed as *anemophilous* and *zooidiophilous*, in conformity with their adaptation to pollination by one or other of these agencies.

Methods of cross-pollination.

Anemophilous flowers are characterized by the prodigal production of powdery pollen, much of which never reaches its proper destination, and the pollen-grains themselves are smooth and light. The anthers as the distributing organs are freely exposed, and the outgo of the pollen-grains in suitable weather is facilitated by such means as the assemblage of the flowers in catkins, their hanging from slender pedicels, long slender filaments to the anther, explosive mechanisms in the flower, and similar arrangements. The reception of the pollen is aided by a free and extensive entangling stigmatic surface, produced by copious branching of the style. Bright colours, nectar-glands giving honey, odour, and generally conspicuousness, are more or less absent. Many flowers, however, which are anemophilous may be also zooidiophilous. There is no doubt that the fertilization of many flowers is affected by animals in their transit over the areas upon which the plants are growing. Such pollinations are, however, entirely fortuitous. On the other hand, the majority of flowers are regularly visited by insects of many kinds, and these insects effect pollination. Such flowers are entomophilous, and are the chief zooidiophilous ones. Here conspicuousness of some kind is a primary requirement for the securing of insect-visits, and this may be effected in various ways, for example, by size and form of individual flower, by aggregation of flowers in inflorescences, by coloured and glistening surfaces in the flower or in the neighbouring parts. Doubtless the most potent lure is odour, and alike in connexion with it and with colour it is probable our senses do not appreciate scents and colours which are recognizable by insects. The gain to the insect by its visit is the honey, which is often protected in elaborate fashion, so that only insects of special form can secure it, and the pollen itself. In seeking for the honey the insect becomes dusted with pollen-grains from the anthers—which are found in positions in relation to the whole form of the flower such that this dusting of the body of a suitable insect is readily effected, the pollen-grains themselves having commonly more or less tuberculated surfaces, and being somewhat sticky—and it carries them to the stigma of flowers subsequently visited. Birds sometimes effect pollination of flowers (*ornithophilous*), snails are also sometimes the agents (*malacophilous*), and other animals—in all of these cases the attraction of food brings the animal to the flower. The relationships of flowers to animals, especially insects, are infinite in variety, and are the subject of a copious literature. Pollination by insects is a prevalent method of cross-pollination at the present epoch, and stands in correlation with the evolution of the angiospermous flower. It is manifestly a more certain and more economical one than pollination by wind. Its hazard is the absence of the proper insect, especially in cases where the form-development is such that but few species of insects can effect it. Pollination by wind is a more primitive method. Pollination in the ways described must often result in the application of pollen-grains of one species upon the stigma of another. Such foreign pollen is frequently sterile upon the stigma, and no result follows. There is also a prepotency in its own pollen belonging to every species, and the application of one grain of it will render futile the germination of any foreign pollen upon its stigma. If such pollination by foreign pollen is followed by the completion of the sexual act, and an embryo is formed, the offspring will be a *hybrid*. In nature such hybrids between allied forms are common, and they are readily produced in cultivation. They may in time be the starting-point of specific forms. Generic hybrids are not so common in nature, but in certain families of Angiosperms quite a number have been produced in horticultural practice.

Second germination of micro-spore.

Pollination having been effected, the pollen-grain moistened by the viscid secretion upon the stigma resumes active growth. The intine investing the vegetative energid is protruded through one of the germ-pores as the pollen-tube, and apparently under chemiotactic influence grows downwards through the style, dissolving its tissue by the aid of an enzyme. The vegetative energid is found at the tip of the tube, and in dicotyledonous plants is followed out of the spore by the male gametes, in monocotyledonous plants by the generative energid which then divides in the tube and forms a pair of gametes. The pollen-tube reaches the cavity of the ovary and commonly passes along the placenta, guided by projections or hairs, to the micropyle of the ovule; this it enters, and dissolving its way through any cells of the nucellus intervening between it and the apex of the embryo-sac, it pierces the latter. This piercing, however, is not always necessary, for the egg-apparatus may have developed so as to rupture the embryo-sac, and even the apex of the

Fertilization.

nucellus, so that it projects into or beyond the micropyle. By this time the two male gametes have passed the degenerated vegetative energid and are at the apex of the tube, and this now being softened they escape into the plasm of the embryo-sac. The gametes, as observed in recent investigations, have vermiform nuclei somewhat thickened at the end, and exhibit a finely porose structure; they are not unlike the spermatozoids of some Pteridophytes, and they are sometimes so named, but their independent movement, without or by means of cilia, has not been observed. One of the male gametes thus discharged, reaches the egg and impregnates it. The fate of the other was until recently not traced, and it was supposed to disintegrate in the plasm of the embryo-sac, or occasionally to coalesce with synergidæ. We now know, however, that in several plants it passes downwards, perhaps passively transported by the streaming of the protoplasm in the embryo-sac, to the two polar energids which have not yet coalesced, and it unites with the apical polar one, or it may await their coalescence, and then unite with their combination—the definite energid of the embryo-sac. The fusion of the second male gamete apparently precedes the impregnation of the egg by the first male gamete. This remarkable *double fertilization* as it has been called, although only recently discovered, has been proved to take place in widely separated families, and both in Monocotyledones and Dicotyledones, and there is every probability that, perhaps with variations, it is the normal process in Angiosperms. It gives a history of the second male gamete. Whilst the pollen-tube normally reaches the apex of the embryo-sac through the micropyle (*acrogamy* or *porogamy*), it may pierce the embryo-sac at the chalazal end or at the side (*basigamy* or *chalasogamy*) by entering the base of the nucellus and making its way upwards, using as passages, it may be, the cavities of aborting embryo-sacs. After impregnation the fertilized egg segments to form the embryo, the synergidæ having long before disintegrated, and the impregnated definite energid also enters sooner or later upon division which results in the formation of endosperm; the antipodal cells often disintegrate at the same time, though they may undergo multiplication first. It has long been known, that after fertilization of the egg has taken place the formation of endosperm begins from the definite energid, and this had come to be regarded as the recommencement of the development of prothallus after a pause following the reinvigorating union of the polar energids. This view is still maintained by those who differentiate the two fertilizations within the embryo-sac, and regard that of the egg by the first male gamete, as the true or generative fertilization, and that of the polar energids by the second male gamete as a vegetative fertilization which gives a stimulus to development in correlation with the other. If, on the other hand, the endosperm is the product of an act of fertilization as definite as that giving rise to the embryo itself, we have to recognize that twin plants are produced within the embryo-sac—one, the embryo, which becomes the angiospermous plant, the other, the endosperm, a short-lived undifferentiated nurse to assist in the nutrition of the former, even as the subsidiary embryos in a pluriembryonic Gymnosperm may facilitate the nutrition of the dominant one. If this is so, and the endosperm like the embryo is normally the product of a sexual act, hybridization will give a hybrid endosperm as it does a hybrid embryo, and herein (it is suggested) we may have the explanation of the phenomenon of xenia observed in the mixed endosperms of hybrid races of maize and other plants regarding which it has only been possible hitherto to assert that they were indications of the extension of the influence of the pollen beyond the egg and its product. This would not, however, explain the formation of fruits intermediate in size and colour between those of crossed parents. The signification of the coalescence of the polar energids is not explained by these new facts, but it is noteworthy that the second male gamete is said to unite sometimes with the apical polar energid, the sister of the egg, before the union of this with the basal polar one. The idea of the endosperm as a second subsidiary plant is no new one; it was suggested long ago in explanation of the coalescence of the polar energids, but it was then based on the assumption that these energids were male and female gametes, for which there was no evidence, and which was inherently improbable. The proof of a coalescence of the second male gamete with the definite energid gives the conception a more stable basis.

Embryogeny.

By the segmentation of the fertilized egg, now invested by cell-membrane, the embryo-plant arises. A varying number of transverse segment-walls transform it into a *pro-embryo*—a cellular row of which the micropylar cell becomes attached to the apex of the embryo-sac, and thus fixes the position of the developing embryo, and the terminal cell is projected into its cavity. In Dicotyledones the shoot of the embryo is wholly derived from the terminal cell of the pro-embryo, from the next cell the root arises, and the remaining ones form the *suspensor*. In many Monocotyledones the terminal cell appears to form the cotyledenary portion alone of the shoot of the embryo, its axial part and the root being derived from the adjacent cell; the cotyledon would thus be a terminal structure and the apex of the primary stem a lateral one—a condition in marked contrast with that of the Dicotyledones. It is known, however, that in many Monocotyledones the cotyledon is not really terminal. The primary root of the embryo in all Angiosperms points towards the micropyle. The developing embryo at the end of the suspensor grows out to a varying extent into the forming endosperm, from which by surface absorption it derives plastic material for growth; at the same time the suspensor probably plays a direct part as a carrier of nutrition and may even develop, where perhaps no endosperm is formed, special absorptive "suspensor roots" which invest the developing embryo or pass out into the body and coats of the ovule, or even into the placenta. In some cases the embryo or the embryo-sac sends out haustoria into the nucellus and ovular integument. As the embryo develops it may absorb all the plastic material available, and store either in its cotyledons or in its hypocotyl what is not immediately required for growth as reserve-food for use in germination, and by so doing it increases in size until it may fill entirely the embryo-sac; or its absorptive power at this stage may be limited to what is necessary for growth and it remains of relatively small size, occupying but a small area of the embryo-sac which is otherwise filled with endosperm in which the reserve-food is stored. There are also intermediate states. The position of the embryo in relation to the endosperm varies, sometimes it is internal, sometimes external, but the significance of this has not yet been established. *Apogamy* sometimes occurs in Angiosperms. As a rule the embryonic shoots are developed from the nucellar wall, or from the synergidæ, or from the antipodal cells, and polyembryony is the result. In *Erythronium*, however, polyembryony is the result of a process recalling features of Gymnosperms, for the embryos arise from the segmentation of the terminal cell of the suspensor—that which normally produces the one embryo. True parthenogenetic apogamy is said to occur in *Antennaria alpina*.

The formation of endosperm starts, as has been stated,

Endosperm.

from the definite energid of the embryo-sac, and the process of double fertilization above described gives new interest to its development. The segmentation of the fertilized definite energid always begins before that of the egg, and thus there is timely preparation for the nursing of the young embryo. If in its extension to contain the new formations within it the embryo-sac remain narrow, endosperm formation proceeds upon the lines of a cell-division, but in wide embryo-sacs the endosperm is first of all formed as a colony of energids (cœnobium), and only gradually acquires a pluricellular character, the change starting from the sides or ends of the embryo-sac. The function of the endosperm is primarily that of nourishing the embryo, and its basal position in the embryo-sac places it favourably for the absorption of plastic material entering the ovule. Its duration varies with the precocity of the embryo. It may be wholly absorbed by the progressive growth of the embryo within the embryo-sac, or it may persist as a definite and more or less conspicuous constituent of the seed. When it persists as a massive element of the seed its nutritive function is usually apparent, for there is accumulated within its cells reserve-food, and according to the dominant substance it may be starchy, oily, cellulosic, aleuronic, and so forth. In cases where the embryo has stored reserve-food within itself and thus provided for self-nutrition, such endosperm as remains in the seed may take on other functions, for instance that of water-absorption.

Fruit and seed.

Dissemination.

As the development of embryo and endosperm proceeds within the embryo-sac, its wall enlarges and commonly absorbs the substance of the nucellus (which is likewise enlarging) to near its outer limit, and combines with it and the integument to form the *seed-coat*; or the whole nucellus and even the integument may be absorbed. In some plants the nucellus is not thus absorbed, but itself becomes a seat of deposit of reserve-food constituting the *perisperm* which may coexist with endosperm, or may alone form a food-reserve for the embryo. Endospermic food-reserve has evident advantages over perispermic, and the latter is comparatively rarely found and only in non-progressive series. Seeds in which endosperm or perisperm or both are said to exist are commonly called *albuminous*, those in which neither is found are termed *exalbuminous*. These terms, extensively used by systematists, only refer, however, to the grosser features of the seed, and indicate the more or less evident occurrence of a food-reserve; many so-called exalbuminous seeds show to microscopic examination a distinct endosperm which may have other than a nutritive function. The character of the seed-coat bears a definite relation to that of the fruit which is derived from the ovary, and it may be from accessory parts as well. Their function is the twofold one of protecting the embryo and of aiding in dissemination; they may also directly promote germination. If the fruit is a dehiscent one and the seed is therefore soon exposed, the seed-coat has to provide for the protection of the embryo and may also have to secure dissemination. On the other hand indehiscent fruits discharge these functions for the embryo, and the seed-coat is only slightly developed. Dissemination is effected by the agency of water, of air, of animals—and fruits and seeds are therefore grouped in respect of this as hydrophilous, anemophilous, and zooidiophilous. The needs for these are obvious—buoyancy in water and resistance to wetting for the first, some form of parachute for the second, and some attaching mechanism or attractive structure for the third. The methods in which these are provided are of infinite variety, and any and every part of the flower and of the inflorescence may be called into requisition to supply the adaptation. Special outgrowths, *arils*, of the seed-coat are of frequent occurrence. In the feature of fruit and seed by which the distribution of Angiosperms is effected we have a distinctive character of the class. In Gymnosperms we have seeds, and the carpels may become modified and close around these, as in *Pinus*, during the process of ripening to form an imitation of a box-like fruit which subsequently opening allows the seeds to escape; but there is never in them the closed ovary investing from the outset the ovules, and ultimately forming the groundwork of the fruit.

Germination of seed.

Their fortuitous dissemination does not always bring seeds upon a suitable nidus for germination, the primary essential of which is a sufficiency of moisture, and the duration of vitality of the embryo is a point of interest. Some seeds retain vitality for a period of many years, though there is no warrant for the popular notion that genuine "mummy wheat" will germinate; on the other hand some seeds lose vitality in little more than a year. Further, the older the seed the more slow as a general rule will germination be in starting, but there are notable exceptions. This pause, often of so long duration, in the growth of the embryo between the time of its perfect development within the seed and the moment of germination, is one of the remarkable and distinctive features of the life of Spermophytes. The aim of germination is the fixing of the embryo in the soil, effected usually by means of the root, which is the first part of the embryo to appear, in preparation for the elongation of the epicotyledonary portion of the shoot, and there is infinite variety in the details of the process. In albuminous Dicotyledones the cotyledons act as the absorbents of the reserve-food of the seed and are commonly brought above ground (*epigeous*), either withdrawn from the seed-coat or carrying it upon them, and then they serve as the first green organs of the plant. The hypocotyl commonly plays the greater part in bringing this about. Exalbuminous Dicotyledones usually store reserve-food in their cotyledons, which may in germination remain below ground (*hypogeous*). In albuminous Monocotyledones the cotyledon itself, probably in consequence of its terminal position, is commonly the agent by which the embryo is thrust out of the seed, and it may function solely as a feeder, its extremity developing as a sucker through which the endosperm is absorbed, or it may become the first green organ, the terminal sucker dropping off with the seed-coat when the endosperm is exhausted. Exalbuminous Monocotyledones are either hydrophytes or strongly hygrophilous plants and have often peculiar features in germination.

It has been possible here only to depict what appear to be general features of sexual reproduction in Angiosperms, and these after all rest upon observation within only a limited circle of forms. A new chapter in the history of our knowledge of the changes in the embryo-sac is opened by the discovery of double fertilization, and the whole subject requires reinvestigation.

Agamogenetic reproduction.

Distribution by seed appears to satisfy so well the requirements of geophilous Angiosperms that distribution by vegetative buds is only an occasional process. At the same time every bud on a shoot has the capacity to form a new plant if placed in suitable conditions, as the horticultural practice of propagation by cuttings shows; in nature we see plants spreading by the rooting of their shoots, and buds we know may be freely formed not only on stems but on leaves and on roots. Where detachable buds are produced, which can be transported through the air to a distance, each of them is an incipient shoot which may have a root, and there is always reserve-food stored in some part of it. In essentials such a bud resembles a seed. A relation between such vegetative distribution buds and production of flower is usually marked. Where there is free formation of buds there is little flower and commonly no seed, and the converse is also the case. Viviparous plants are an illustration of substitution of vegetative buds for flower.

II. *Aerophytes.*—The œcological category of Aerophytes is a much smaller one than that of Geophytes, and, unlike the latter, they are not affected by edaphic environment. An aerophyte is an autotrophic plant growing upon another, to which it is commonly fixed by its roots. The term *epiphyte*, commonly given to them, is so frequently used to designate the position of saprophytes and parasites upon host-plants, that it is better avoided as the name of the œcological category we are dealing with. Aerophytes are found amongst both Dicotyledones and Monocotyledones and in many families. They may be herbs, shrubs, or trees. They are derived from geophytes, and their mode of life, while it enables them to reach better conditions of light, makes them dependent wholly upon epedaphic environment, and their distribution over the world is markedly contingent upon a supply of atmospheric moisture. Their home is the damp woods of the tropics and of the warm temperate regions. The conditions of life of an aerophyte make its supply of water somewhat precarious; it has therefore to provide for the protection of what it secures, and for the rapid absorption of any coming within reach. For the former of these purposes it most commonly has some form of water-storage which gives it succulence in leaf or stem; the cuticle is thick and the stomata are sunk, and a coating of hairs is found occasionally though rarely. For the latter purpose the roots, which are frequently copious, often have a velamen; exposed to light they form chlorophyll and become accessory organs of carbon-dioxide-assimilation, or they may take on the whole duty of this, the leaves being then suppressed. Sometimes in rootless forms absorptive hairs enable the plant to take water by its whole surface. The seed of an aerophyte usually germinates upon the supporting plant, and it is rare for a geophyte subsequently to become an aerophyte; on the other hand several cases are known of a juvenile aerophyte becoming a geophyte when older, and smothering its nurse as it descends to the soil. These plants are therefore only *hemiaerophytes.* In some aerophilous Bromeliads the rosette of leaves forms a cup in which water collects; into this débris both organic and inorganic falls, and produces a nutrient solution in which hydrophytes like *Utricularia* may live. The Bromeliad absorbs this fluid by special hairs, and is therefore a partial saprophyte; its roots are only anchoring organs. Such plants are called *Tank Aerophytes.* A somewhat similar condition, differing only in soil being collected instead of water, is seen in *Nest Aerophytes.* Here some roots or leaves form, with the stem of the supporting plant, a receptacle in which débris accumulates and makes a soil into which feeding roots from the aerophyte pass; in this case there is an approach to the geophytes. Many aerophytes have brilliant flowers highly specialized for entomophilous pollination. The seeds are small and light, or have flight arils or a succulent fruit-envelope, and can readily enter a crack of tree-bark. Dissemination is anemophilous or zooidiophilous, sometimes also the rain may be the agent. Vegetative propagation hardly exists, but portions of the shoot of *Tillandsia usneoides* are said to be carried by wind and birds.

III. *Hydrophytes.*—Plants of the œcological category of Hydrophytes dwell in a more uniform environment than is the lot of Geophytes or Aerophytes, and hydrophilous features are found in many cycles of affinity amongst Dicotyledones and Monocotyledones. Typical hydrophytes live submerged in water. Their general physiognomy is that of delicate flexible herbs which rapidly shrivel on exposure to the air. In their environment their water-supply is not a first charge upon the organization, because diffusion can take place at every point, but the gaseous supply, owing to the slow diffusion of air in water, and the supply of radiant energy, owing to the feeble penetration of light, are matters of first moment. Further, the density of the medium reduces the need of intrinsic support. To those conditions hydrophytes are adapted first of all by an extension of the shoot-surface, secured by elongation of the leaves into a riband form in moving water, or by their division into filiform segments in still water; at the same time the system of air-canals is greatly developed. Then the chlorophyll apparatus lies in the peripheral layers of the organism, palisade-tissue being absent, and the strengthening tissue is always reduced in amount, and so forth. In the absence of transpiration there is a reduction or, it may be, a suppression of the root-system, and it is often only developed as an anchoring organ. No stomata are formed upon the shoot, and the cuticle is everywhere only feebly formed. The carrying system too is greatly simplified, both by reduction of the number of vasa and of their area, and it is concentrated as a central strand in the axis, just as it is in ordinary roots, and thus is favourably placed in relation to the pulling strains to which the shoot is subjected under the currents of water. The growing points are frequently invested by mucilage, which acts as a protection to them. Many of these features of hydrophytes are observable in hygrophilous geophytes, and there are all stages of transition between the two types. Thus when in hydrophytes the flowers are brought above the surface of the water, one or more flat floating leaves may be developed to support the plant at the surface, or the floating leaves may predominate. Floating plants also occur in which the leaves are variously modified to act as floats. In all cases where parts of the shoot reach the air they develop more or less geophytic features. Amongst the most remarkable of hydrophytes are the Podostemaceæ—tropical dicotyledonous plants of cascades and rapidly flowing water. They have the habit of Bryophytes. The root forms a branched dorsiventral chlorophyllous thallus-like structure, attached by hairs and special branches (*haptera*) to rocks, and it is the chief structure for the assimilation of carbon dioxide. The shoots, which are also commonly dorsiventral, arise as outgrowths from it and bear small, usually divided, leaves. Marine hydrophytes which are subject to exposure between tides have often some of the xerophilous features of halophytes. In their flower-structure typical hydrophytes show great simplification where the flowers are persistently submerged. They are frequently unisexual and the flower-envelopes are reduced. For subaqueous pollination the pollen is often vermiform of about the same specific gravity as the water, whilst the styles are long and filiform so as to increase the chances of the act being accomplished. Sometimes pollination takes place on the surface of the water, and then in various ways the pollen is brought to the surface, where it comes in contact with the stigmas. Often the flowers are raised in the air above the water, and then they exhibit the features of anemophily or zooidiophily. Many hydrophytes have embryos of peculiar form and remarkable germination. Amongst Monocotyledones most hydrophytes are exalbuminous and the embryos are macropodous through storage of food-material. Vegetative propagation by the detachment of portions of the shoots or of definite buds is not uncommon amongst hydrophytes, and these, readily carried by water-currents, serve as a means of distribution. To this circumstance is probably due the wide area of distribution of many hydrophytes.

Autotrophism and heterotrophism.

A typical Angiosperm is an *autotrophic* (prototrophic) plant. By this we mean that it is able to build up its organic food-material within itself from inorganic substances taken by it from without. In the early juvenile phases of their life, however, many such autotrophic Angiosperms are *heterotrophic*, that is to say, they take in their organic food-material from without, inasmuch as they feed in germination upon reserve-food stored up within the seed, frequently by means of a special sucker produced by the cotyledon. This is after all only a case of prolongation of the nursing process common to all embryos, and of the drawing of food from one set of cells to another which is characteristic of the higher plants in consequence of their colonial organization. On the other hand some Angiosperms are persistently heterotrophic, either as *saprophytes* (metatrophic) or as *parasites* (paratrophic), and this manner of life involves some kind of *symbiosis*. Between truly autotrophic Angiosperms and truly heterotrophic ones there are all degrees, and such intermediate forms have been designated *mixotrophic*.

Saprophytism.

A typical saprophyte is a plant which derives its food-material from dead organic matter. This method of feeding is associated with the presence of the mycelium of a fungus attached to the absorbing system and forming a *mycorhiza*, and there is a *reciprocal symbiosis* between the Angiosperm and the fungus which is *endophytic*, only rarely *ectophytic*. Reduction of the vegetative system of the Angiosperm accompanies this. The subterranean portion of the plant is small and the roots may be absent. In the shoot chlorophyll is suppressed, and commonly a brown pigment, the use of which is unknown, is present; there are only scale-leaves, and the carrying system is rudimentary. Such typical saprophytes are *holosaprophytes*. Where chlorophyll is present in small amount the plant is able to manufacture some at least of its carbonaceous food and is then a *hemisaprophyte*. Angiospermous holosaprophytes are not common. They are known amongst Gentianeæ and Monotropeæ only of Dicotyledones, and most of them are Monocotyledones of the Orchideæ, Burmanniaceæ, and Triurideæ. They are derived from autotrophic forms and do not appear to be associated with any special climatic conditions, but, as their structure would suggest, are most of them plants of shade and moisture. A large number of Angiosperms which appear to be independent autotrophic forms are now known to engage in a form of symbiosis, the exact relations in which are not yet determined. More or fewer of their rootlets have their extremities invested by a weft of hyphal mycelium as an *ectophytic mycorhiza*. This is not constant in one species, nor do all rootlets of one plant show it. Its frequency, however, indicates some reciprocal relation between the Angiosperm and the fungus. The occurrence of *mycodomatia* upon the roots of plants of Leguminosæ as well as of other families is a result of a symbiosis, and is of supreme importance in agriculture on account of the accumulation of nitrogenous material that takes place within them. The fact known to gardeners that, as the wood of tubs in which large plants are grown gradually decays, the roots of the occupant spread into it and there develop mycorhiza, usually endophytic, points in the direction of the facultative saprophytism of all Angiosperms. The habit possessed by a few plants of different cycles of affinity of capturing insects in traps of various kinds, enables them to obtain an accession to their supply of nitrogen. In some of them a proteolytic enzyme brings about the digestion of the insect for the benefit of the plant (Droseraceæ, Nepenthaceæ), in other cases there appears to be no enzyme, and the plant absorbs soluble nitrogenous substances formed in normal putrefaction (Sarraceniaceæ). Some carnivorous plants are hydrophytes (Utricularia). The flower-structure of typical saprophytes has no feature of special interest, but it is much to be wished that we had full knowledge of the changes in the embryo-sac and of the phases of embryogeny.

Parasitism.

A parasite takes all or a portion of its food-material from a living *host* into which it penetrates. The degree of connexion between the two and the dependence of the parasite upon the host vary between the completeness of that of *holoparasitic* Rhizanths, in which little more than the flower of the parasite is visible upon the outside of the stem of the host and the parasitism is absolute, and the limitation of that of the *hemiparasitic* Rhinantheæ, in which to all appearance there is an independent autotrophic geophyte, for it possesses chlorophyll and its union with the host is confined to isolated points below ground. The seat of attachment of the parasite may be either the root or the stem of the host; sometimes, in the case of twining parasites, the leaf may also be made use of. In the simplest cases the parasite develops a sucker (*haustorium*), from the centre of which piercing connexions of kinds proceed, and it then maintains its individual shoot development, which may be that of a herb (annual or perennial), shrub, tree, or liane, outside the host. But in the more advanced conditions of parasitism the reduction of the vegetative system of the parasite is so great that its individuality outside the host is lost, and it appears as a web of threads running within and blending with the tissues of the host, in the manner of a mycelium, or forming with the tissue of the host a tuberous conjoint stock from which the reproductive system shoots. All angiospermous parasites are derived from autotrophic forms, but the modification in the form and structure of their organs—both vegetative and reproductive—induced by the parasitism, makes the relation of holoparasitic groups somewhat obscure. Parasitism is unknown amongst Monocotyledones, but has appeared more than once amongst Dicotyledones. Cytineæ, Balanophoreæ, Orobanchaceæ, Lennoaceæ, are families of differing position which are characteristically holoparasitic. Loranthaceæ and Santalaceæ are chiefly hemiparasitic, as are most of the parasitic Scrophularineæ. Parasitism is not associated with any special epedaphic conditions, and there are no hydrophilous parasites. It occurs in all regions of the world, and in the varying environment of dark damp tropical woods, arid plains of warm regions, tropophil woods of temperate regions, and alpine slopes. Accordingly both xerophilous and hygrophilous features appear. The host in some cases seems to have no particular attraction to the parasite, and any species of plant may be used by the same specific parasite, even its own body being acceptable; on the other hand, there are parasitic species which are only known upon one kind of host. Of the factors which co-operate in bringing about the attachment of a parasite to its host we know nothing beyond the fact that chemiotactic and contact stimuli are, as in all cases of infection, concerned in it. The life of the host may or may not be affected by the parasite. Species of *Cuscuta*, if they do not kill, may so arrest the growth of their host-plant as to bring about results disastrous in agriculture, and by the penetration of loranthaceous plants deformities of stem and branches are produced in trees, which then become useless for timber. It has been claimed that in the case of chlorophyllaceous parasites, the symbiosis may not be *antagonistic* but *reciprocal*, but even if this be so to some extent, the amount of aid rendered to the host does not compensate for the drain upon its resources made by the parasite. So conspicuous is this that legislation restricting the cultivation of mistletoe, on account of the damage caused by it in orchards, has been deemed necessary in some districts in Europe. In the more recently derived parasites, those of bicarpellate gamopetalous Dicotyledones, most of which are hemiparasitic and epirhizal, the flower-structure and seed-formation retain in the main their immediate ancestral features, but in the families of the Loranthales, to which all evidence concurs in ascribing a far back origin, many modifications in the way of reduction are found. The inflorescence may be endogenetic, the ovule may consist of nucellus alone, and frequently there is no ovule—the embryo-sacs, of which there are many, being then developed in the torus or in the ovarian wall. The formation of endosperm offers many features of interest, one of the most remarkable being that seen in *Balanophora*, where the apical polar energid alone of the energids within the embryo-sac survives disintegration, and then, in the absence of fertilization, segments to form a pluricellular endosperm upon which an embryo apogamously buds. The history of few forms is well known, and these require re-study in the light of the recently-acquired knowledge of fertilization. There is no more promising field for investigation than that of the embryogeny of parasites.

Myrmecophily.

Intimate relations between Angiosperms and the animal kingdom have been shown to exist in the work of pollination, of dissemination, and of the feeding of carnivorous plants. Another relation of which the facts are clear enough, but of which the evolution is doubtful, is that known as *Myrmecophily*. Species of ants make their home on tropical plants, living in hollows of stem, petiole, or stipule, which are commonly enlarged and may form tuberous cushions. They feed upon either the secretion of extra-floral nectaries, or upon the richly nitrogenous contents of modified glands (*Müller's corpuscles*), which are borne upon some part of the leaves, and which are continuously renewed during the life of the leaf. These ants act as a bodyguard to their home against the inroad of leaf-cutting ants collecting material for their fungus-gardens. These remarkable relationships have naturally led to the assumption that there is causal connexion between the ants and the plant-structures, a view for which there is, however, no sufficient evidence.

Phylogeny and taxonomy.

The position of Angiosperms as the highest plant-group is unassailable, but of the point or points of their origin from the general stem of the plant kingdom, and of the path or paths of their evolution, we can as yet say little. Until well on in the Mesozoic period geological history tells us nothing about Angiosperms, and then only by their vegetative organs. We readily recognize in them nowadays the natural classes of Dicotyledones and Monocotyledones distinguished alike in vegetative and in reproductive construction, yet showing remarkable parallel sequences in development; and we see that the Dicotyledones are the more advanced and show the greater capacity for further progressive evolution. But there is no sound basis for the assumption that the Dicotyledones are derived from Monocotyledones; indeed, the palæontological evidence seems to point to the Dicotyledones being the older. This, however, does not entitle us to assume the origin of Monocotyledones from Dicotyledones, although there is manifestly a temptation to connect helobic forms of the former with ranal ones of the latter. There is no doubt that the phylum of Angiosperms has not sprung from that of Gymnosperms.

Within each class the flower-characters as the essential feature of Angiosperms supply the clue to phylogeny, but the uncertainty regarding the construction of the primitive angiospermous flower gives a fundamental point of divergence in attempts to construct progressive sequences of the families. Simplicity of flower-structure has appeared to some to be always primitive, whilst by others it has been taken to be always derived. There is, however, abundant evidence that it may have the one or the other character in different cases. Apart from this, botanists are generally agreed that the concrescence of parts of the flower-whorls—in the gynæceum as the seed-covering, and in the corolla as the seat of attraction, more than in the andrœcium and the calyx—is an indication of advance, as is also the concrescence that gives the condition of epigyny. Dorsiventrality is also clearly derived from radial construction, and anatropy of the ovule has followed atropy. We should expect the albuminous state of the seed to be an antecedent one to the exalbuminous condition, and the recent discoveries in fertilization tend to confirm this view. Amongst Dicotyledones the gamopetalous forms are admitted to be the highest development and a dominant one of our epoch. Advance has been along two lines, markedly in relation to insect-pollination, one of which has culminated in the hypogynous epipetalous bicarpellate forms with dorsiventral often large and loosely arranged flowers, and the other in the epigynous bicarpellate small-flowered families of the Aggregatæ. In the polypetalous forms progression from hypogyny to epigyny is generally recognized, and where dorsiventrality with insect-pollination has been established, a dominant group has been developed as in the Leguminosæ. The starting-point of the class, however, and the position within it of apetalous families with frequently unisexual flowers have provoked endless discussion, and there is no uniformity in opinion upon these matters. In Monocotyledones a similar advance from hypogyny to epigyny is observed both in a geo-aerophilous and in a hydrophilous series, but the class does not appear to be now progressive. In this connexion it is noteworthy that so many of the higher forms are adapted as bulbous geophytes, or as aerophytes to special xerophilous conditions. The Gramineæ offer a prominent example of a dominant self-pollinated or wind-pollinated family, and this may find explanation in a multiplicity of factors.

From an early period in the century systematists have been endeavouring to group the families of the two classes of Angiosperms in larger associations under such designations as Alliance, Cohort, Series, and such endeavours were in the direction of discovering real phyla—although in the pre-Darwinian period the idea was not always present. The relationship of some families is so clear that there has never been any doubt about their forming phyletic groups, but on the other hand there are many, either isolated or of reduced type, the position of which has been and in very many cases is still open to discussion, and consequently the limits of these phyla—like the limits of families, genera, and species—have been variously assigned by different botanists according to their particular views and to the knowledge of their time. The arrangement by botanists of these phyla in larger groups has given us different systems which, if they all lay claim to associating in some measure natural groups, vary in the degree to which convenience or genetic relation—real or imagined—has influenced them. In Great Britain the system adopted by Bentham and Hooker—itself framed upon that of De Candolle, which in turn owed its origin to Jussieu—holds sway, with some modification, fortified as it is by the detailed description in their magnificent work—the *Genera Plantarum*—of all genera known at the time of writing. It is:—

Dicotyledones.
POLYPETALÆ { *Thalamifloræ.* *Discifloræ.* *Calycifloræ.*
GAMOPETALÆ { *Inferæ.* *Heteromeræ.* *Bicarpellatæ.*
MONOCHLAMYDEÆ.
GYMNOSPERMÆ.
Monocotyledones.

The inclusion of Gymnosperms amongst Dicotyledones was more a conforming with conventional practice than the expression of an opinion of genetic relationships which were recognized as cryptogamic. Apart from this, the grouping in the Polypetalæ and Gamopetalæ indicates in the main the lines of progression of Angiosperms; the juxtaposition of Inferæ and Calycifloræ being adopted to bring into prominence the similarities of facies between the flower-features of the highest Polypetalæ and the aggregate Gamopetalæ. The Monochlamydeæ, on the other hand, was retained as a convenient group for apetalous and often unisexual families, the relationships of many of which were and are doubtful, although the connexion of some of them with polypetalous families was clearly pointed out. In Germany there has recently been completed *Die Natürlichen Pflanzenfamilien*—a book made possible by Bentham's and Hooker's labours—the combined work of many botanists under the editorial guidance of Engler and Prantl. It gives brief diagnoses of all known genera. The system adopted in it is:—

Dicotyledones.
ARCHICHLAMYDEÆ (*Choripetalæ and Apetalæ*).
METACHLAMYDEÆ (*Sympetalæ*).
Monocotyledones.

In this system the Apetalæ disappear as a group, and the families are assigned their positions in the several phyla or series, as they are termed, to which in the views of the writers they belong. The series are arranged in genetic sequence, so far as a linear arrangement permits of this, beginning with Casuarineæ and Piperaceæ which are regarded as the most primitive forms extant. As an attempt at a phylogenetic arrangement this system is now preferred by many botanists, particularly in America. More recently a startling novelty in the way of system has been produced by Van Tieghem, as follows:—

Monocotyledones.
Liorhizal Dicotyledones.
Dicotyledones.
INSEMINEÆ.
SEMINEÆ.
Unitegmineæ.
Bitegmineæ.

The most remarkable feature here is the class of Liorhizal Dicotyledones, which includes only the families of Nymphæaceæ and Gramineæ. It is based upon the fact that the histological differentiation of the epidermis of their root is monocotyledonous, whilst they have two cotyledons—the old view of the epiblast as a second cotyledon in Gramineæ being adopted. But recent investigation shows that the embryo of Nymphæaceæ is monocotyledonous, and the adult root-character is only confirmation of this, and whatever the epiblast be it is not a constant feature of grass-embryos. Ovular characters determine the grouping in the Dicotyledones, Van Tieghem supporting the view that the integument, the outer if there be two, is the lamina of a leaf of which the funicle is the petiole, whilst the nucellus is an outgrowth of this leaf, and the inner integument, if present, an indusium. The Inseminæ include forms in which the nucellus is not developed, and therefore there can be no seed. The plants included are, however, mainly well-established parasites, and the absence of nucellus is only one of those characters of reduction to which parasites are liable. Even if we admit Van Tieghem's interpretation of the integuments to be correct, the diagnostic mark of his unitegminous and bitegminous groups is simply that of the absence or presence of an indusium, not a character of great value elsewhere, and, as we know, the number of the ovular coats is inconstant within the same family. At the same time the groups based upon the integuments are of much the same extent as the Polypetalæ and Gamopetalæ of other systems. We do not yet know the significance of this correlation between number of integuments and union of petals.

The reader will find in the following works details of the subject and references to the literature:—DE BARY. *Comparative Anatomy of Phanerogams and Ferns.* English ed. Oxford, 1884.—BENTHAM and HOOKER. *Genera Plantarum.* London, 1862-83.—EICHLER. *Blüthendiagramme.* Leipzig, 1875-78.—ENGLER and PRANTL. *Die natürlichen Pflanzenfamilien.* Leipzig, 1887-99.—GOEBEL. *Organography of Plants.* English ed. Oxford, 1900 (Part I.).—HABERLANDT. *Physiologische Pflanzenanatomie.* Aufl. ii. Leipzig, 1896.—KNUTH. *Handbuch der Blütenbiologie.* Leipzig, 1898, 1899.—NAWASCHIN. "Ueber die Befrüchtungsvorgänge bei einigen Dicotyledonen," *Ber. d. deutsch. botan. Gesellsch.*, June 1900.—PENZIG. *Pflanzen-Teratologie.* Genua, 1890-94.—PFEFFER. *Physiology of Plants.* English ed. Oxford, 1900.—SACHS. *Lectures on the Physiology of Plants.* English ed. Oxford, 1887.—*History of Botany.* English ed. Oxford, 1890.—SARGANT. "Recent Work on the Results of Fertilization in Angiosperms," *Ann. of Bot.* 1900.—SCHIMPER. *Pflanzen-Geographie auf physiologischer Grundlage.* Jena, 1898.—SEWARD. "Notes on the Geological History of Monocotyledons," *Ann. of Bot.* 1896.—SOLEREDER. *Systematische Anatomie der Dicotyledonen.* Stuttgart, 1899.—VAN TIEGHEM. *Éléments de Botanique.* Paris, 1898.—WARMING. *Plantesamfund.* Kjobenhavn, 1895. German ed., *Lehrbuch der Oekologischen Pflanzengeographie.* Berlin, 1896.—ZEILLER. *Éléments de Palæobotanique.* Paris, 1900. (I. B. B.)

Angkor, Wat. See SIEMRAT and CAMBODIA.

Anglesea or **Anglesey,** an insular county of North Wales, separated from Carnarvon by the narrow channel known as the Menai Strait.

Area and Population.—The area of the ancient and administrative county is 175,836 acres or 275 square miles, with a population in 1881 of 51,416, and in 1901 of 50,590, the number of persons per square mile being 184, and of acres to a person 3·48. The area of the registration county is 120,199 acres with a population in 1891 of 34,219. Within this area the increase of population between 1891 and 1901 was 1·0 per cent. The excess of births over deaths between 1881 and 1891 was 2392, and the decrease in the resident population was 908. The following table gives the number of marriages, births, and deaths, with the number and percentage of illegitimate births for 1880, 1890, and 1899:—

Year.	Marriages.	Births.	Deaths.	Illegitimate Births.	
				No.	Percentage.
1880	217	1023	1023	74	7·3
1890	199	800	729	73	9·1
1899	241	894	592	58	6·5

In 1891 there were in the county 129 natives of Scotland, 409 natives of Ireland, and 71 foreigners, while 2509 could speak English, 23,200 Welsh, and 7281 English and Welsh.

Constitution and Government.—Anglesea returns one member to parliament, and it has now no parliamentary borough. There is one municipal borough, Beaumaris (2310). The following are urban districts: Holyhead (10,072), Llangefni (1751), and Menai Bridge (1600). It is in the North Wales circuit, assizes being held at Beaumaris. There are forty-four ecclesiastical districts or parishes, all in the diocese of Bangor.

Education.—The number of elementary schools on 31st August 1899 was 64, of which 39 were board and 25 voluntary schools, the latter including 22 Church of England schools, 1 Roman Catholic, and 2 "British and other." The average attendance at board schools was 4060, and at voluntary schools 2330. The total school board receipts for the year ending 29th September 1899 were over £14,242. The income under the Agricultural Rates Act was £825.

Agriculture.—About six-sevenths of the total area of the county is under cultivation, and of this, more than half is in permanent pasture. Less than 8000 acres are hill pasture, and only a little more than 2000 acres are under woods. Almost the whole acreage under corn crops is occupied by oats; more than half the green crop acreage is under turnips, and considerably more than a fourth under potatoes. A few acres of flax are usually grown. The preceding table gives the larger main divisions of the cultivated area at intervals of five years from 1880.

Year.	Area under Cultivation.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1880	147,011	26,389	9,468	26,431	84,389	333
1885	148,006	26,639	10,004	27,203	83,975	185
1890	149,451	26,188	10,062	31,724	81,421	50
1895	152,004	24,798	9,305	28,219	89,592	76
1900	152,478	21,712	9,095	44,721	76,810	107

The following table gives particulars regarding the principal live stock for the same years:—

Year.	Total Horses.	Total Cattle.	Cows and Heifers in Milk or in Calf.	Sheep.	Pigs.
1880	7108	48,740	15,047	46,735	13,988
1885	7040	47,299	18,299	47,268	15,579
1890	6947	47,753	15,951	54,382	20,028
1895	7604	49,249	15,884	59,315	18,560
1900	8367	56,653	17,264	82,145	15,438

Industries and Trade.—According to the report for 1898 of the chief inspector of factories (1900), the total number of persons employed in 1897 in textile and non-textile factories and workshops was 997, the number in 1896 being 929; 751 of the 997 were engaged in non-textile factories. The mining industries have been gradually declining, and in 1899 only employed 549 persons. Copper has almost ceased to be worked, but some zinc is still obtained. In 1899 there were raised 61,557 tons of limestone and 23,711 of sandstone.

Fish are plentiful round the whole coast. The fish landed at Holyhead in 1899 amounted to 17,708 cwt., valued at £3288; and the total value, including shell-fish, was £3562.

See ROWLAND, *Mona Antiqua Restaurata.* Dublin, 1723; 2nd edition, London, 1726. *History of Anglesey* (serving as supplement to Rowland's work). London, 1775. See also the various guide-books to North Wales.

Angleur, a town of Belgium, 3 miles by rail S.E. of Liége on the river Vesdre. It is the headquarters of the mining association known as the *Vieille Montagne*, which has zinc foundries here. Population (communal) (1866), 2554; (1880), 4357; (1890), 5902; (1897), 8001.

Anglican Communion.—The Anglican communion consists of the churches of England and Ireland, the Scottish Episcopal Church, and the daughter churches which have sprung from them and are in full communion with them; chief amongst these latter being, of course, the Protestant Episcopal Church of the United States of North America. Until the 19th century these latter were so few in number and so insignificant in size that such a phrase might well have seemed needless: to-day the churches of the Anglican Communion are a power throughout the world. Together they constitute one of the three great historical divisions of Christendom; the others, of course, being the churches of the Roman obedience and those of the Orthodox east. The Church of England was already, in the 8th century, a "mother of churches" on the mainland of Europe, through the work of Willibrord, Boniface, and their followers; after this, however, it suffered from the general stagnation, so far as aggressive work was concerned, which overtook most of western Christendom. Nor did it readily emulate the example of missionary activity shown in the 16th century by the Jesuits. Some care was taken to provide for the immediate spiritual needs of English colonists in America, and many isolated efforts were made to convert the Indians. But the predominant Calvinistic theology was not conducive to missionary work, whilst supposed legal difficulties, and the current theory of Church and State, long prevented the consecration of bishops for the Colonies. Archbishop Laud attempted to obtain a bishop for Virginia. A nomination was actually made by Charles II., and other efforts were put forth in the early part of the 18th century; but they all came to nothing. In spite of increasingly urgent petitions, the Colonies still remained unprovided for. Meanwhile they were theoretically under the care of the bishops of London, who from time to time sent commissaries to America, and ordained young men who were sent to England for the purpose. At length came the War of Independence; and as soon as peace was declared, the church people of Connecticut sent Dr Samuel Seabury to England with a petition to the archbishop of Canterbury for his consecration. But as there were, not unnaturally, political obstacles, Archbishop Moore refused; and they were compelled to turn to the Scottish bishops, by three of whom Dr Seabury was consecrated bishop of Connecticut on 14th November 1784. Soon afterwards, at the initiative of the archbishop, the supposed legal difficulties were removed (26 Geo. III. c. 84); and on being satisfied as to the doctrines of the church, and as to the liturgical changes which were then under discussion in a convention at Philadelphia, the two English archbishops proceeded to consecrate William White and Samuel Prevoost to the sees of Pennsylvania and New York on 14th February 1787. Thus the Protestant Episcopal Church in the United States was properly equipped; and since then its progress has been constant. At the time of Seabury's consecration there were barely 100 Anglican clergymen in the United States: to-day there are in all 91 American bishops and over 5000 clergymen, working either at home or abroad. The American church has never proceeded to the organization of provinces. The presiding bishop is the senior by consecration, and the House of Bishops elects its own chairman.

The Church in the Colonies.

On 12th August 1787 Dr Charles Inglis was consecrated bishop of Nova Scotia, with jurisdiction over all the British possessions in North America. In 1793 the see of Quebec was founded; Jamaica and Barbadoes followed in 1824, and Toronto and Newfoundland in 1839. Meanwhile the needs of India had been tardily met, on the urgent representations in Parliament of William Wilberforce and others, by the consecration of Dr T. F. Middleton as bishop of Calcutta, with three archdeacons to assist him in his labours. In 1817 Ceylon was added to his charge; in 1823 all British subjects in the East Indies and the islands of the Indian Ocean; and in 1824 "New South Wales and its dependencies"! Some five years later, on the nomination of the Duke of Wellington, William Broughton was sent out to work in this enormous jurisdiction as archdeacon of Australia. Soon afterwards, in 1835 and 1837, the sees of Madras and Bombay were founded; whilst in 1836 Broughton himself was consecrated as first bishop of Australia. Thus down to 1840 there were but ten colonial bishops; and of these several were so hampered by civil regulations that they were little more than government chaplains in episcopal orders. In April of that year, however, Bishop Blomfield of London published his famous letter to the archbishop of Canterbury, declaring that "an episcopal church without a bishop is a contradiction in terms," and strenuously advocating a great effort for the extension of the episcopate. It was not in vain. At a meeting held at Willis's Rooms in London, early in 1841, the plan was taken up with enthusiasm, and large subscriptions were promised; and on Whitsun Tuesday of that year the bishops of the United Kingdom met and issued a declaration which inaugurated the Colonial Bishoprics Council. Subsequent declarations, in 1872 and 1891, have served both to record progress and to stimulate to new effort; and since 1841 a sum of about £800,000 has been raised and applied to this object. The diocese of New Zealand was founded in 1841, being endowed by the Church Missionary Society through the Council, and George Augustus Selwyn was chosen as the first bishop. Since then the increase has gone on, as the result both of home effort and of the action of the local churches. Thus St John's Kaffraria was founded by the Scottish Episcopal Church; the foundation of a see in Japan by the Canadian church is in contemplation; and the colonial churches have all done their share. Moreover, the fuller realization of the nature and value of the episcopal office has led to the sending out of bishops to inaugurate new missions, instead of waiting until there is already a large body of clergy and lay people: this procedure has been followed in the cases, amongst others, of the Universities' Mission to Central Africa, Lebombo, Corea, and New Guinea; and the missionary jurisdictions so founded develop in time into dioceses. And thus, instead of the ten colonial jurisdictions of 1841, there are now about a hundred foreign and colonial jurisdictions, in addition to those of the church of the United States. The see of Carpentaria in Australia was founded in 1900, and scarcely a year passes without the addition of one or more to the list. It was only very gradually that these dioceses acquired legislative independence and a determinate organization. At first, sees were created and bishops were nominated by the Crown by means of letters patent; and in some cases an income was assigned out of public funds. In fact, such was the theory of the crown officers as to its inherent rights as the "fount of honour" that Bishop Selwyn only managed by great exertions to prevent the insertion of a clause in his own letters patent reserving the appointment of his archdeacons to the Crown! Moreover, for many years all bishops alike were consecrated in England, took the customary "oath of due obedience" to the archbishop of Canterbury, and were regarded as a species of extra-territorial suffragans of his. But by degrees changes have been made on all these points.

Provincial organization.

(1) Local conditions soon rendered necessary something of the nature of a provincial organization, and it was gradually introduced. The bishop of Calcutta received letters patent as metropolitan of India when the sees of Madras and Bombay were founded; and fresh patents were issued to Bishop Broughton in 1847 and Bishop Gray in 1853, as metropolitans of Australia and South Africa respectively. Similar action was taken in 1858, when Bishop Selwyn became metropolitan of New Zealand; and again in 1860, when, on the petition of the Canadian bishops to the Crown and the colonial legislature for permission to elect a metropolitan, letters patent were issued appointing Bishop Fulford of Montreal to that office. Since then metropolitans have been chosen and provinces formed by regular synodical action. The process has been greatly encouraged by the resolutions of the Lambeth conferences on the subject; and in 1901 the formation of a province of Queensland was in contemplation, with Brisbane as its metropolitan see. The constitution of these provinces is not uniform. In some cases, as South Africa, New South Wales, and Queensland, the metropolitan see is fixed: a practice which is not only in accordance with most ancient precedents, but which secures the inestimable benefit of an unbroken history. Elsewhere, as in Canada and New Zealand, where no single city can claim pre-eminence, the metropolitan is either elected or else is the senior bishop by consecration, whatever his see may be. Two further developments must be mentioned. (*a*) The creation of diocesan and provincial synods, the first diocesan synod to meet being that of New Zealand in 1844, whilst the formation of a provincial synod was foreshadowed by a conference of Australasian bishops at Sydney in 1850. (*b*) In recent years the title of *archbishop* has been given to the metropolitans of several provinces. It was first assumed by the metropolitans of Canada and Rupert Land, at the desire of the Canadian General Synod, in 1893; and subsequently, in accordance with a resolution of the

Lambeth Conference of 1897, it was given to the metropolitans of New South Wales and South Africa by their synods. Civil obstacles have hitherto delayed its adoption by the metropolitan of India.

Freedom from state control.

(2) By degrees, also, the colonial churches have been freed from their rather burdensome relations with the state. The church of the West Indies was disestablished and disendowed in 1868 (ESTABLISHMENT). In 1857 it was decided, in *Regina* v. *Eton College*, that the Crown could not claim the presentation to a living when it had appointed the former incumbent to a colonial bishopric, as it does in the case of an English bishopric. In 1861, after some protest from the Crown lawyers, two missionary bishops were consecrated without letters patent for regions outside British territory: C. F. Mackenzie for the Zambezi region and J. C. Patteson for Melanesia, by the metropolitans of Cape Town and New Zealand respectively. In 1863 the Privy Council declared, in *Long* v. *The Bishop of Cape Town*, that "the Church of England, in places where there is no church established by law, is in the same situation with any other religious body." In 1865 it adjudged Bishop Gray's letters patent, as metropolitan of Cape Town, to be powerless to enable him "to exercise any coercive jurisdiction, or hold any court or tribunal for that purpose," since the colony of South Africa already possessed legislative institutions when they were issued; and since there was no formal compact of obedience between them, his deposition of Bishop Colenso was declared to be "null and void in law." This apparent disaster, as Bishop S. Wilberforce at once foresaw, proved to be "the charter of freedom of the colonial church." The South African bishops forthwith surrendered their patents, and formally accepted Bishop Gray as their metropolitan, an example followed in 1865 in the province of New Zealand. In 1862, when the diocese of Ontario was formed, the bishop was elected in Canada, and consecrated under a royal mandate, letters patent being by this time entirely discredited. And when, in 1867, a coadjutor was chosen for the bishop of Toronto, an application for a royal mandate produced the reply from the Colonial Secretary that "it was not the part of the Crown to interfere in the creation of a new bishop or bishopric, and not consistent with the dignity of the Crown that he should advise Her Majesty to issue a mandate which would not be worth the paper on which it was written, and which, having been sent out to Canada, might be disregarded in the most complete manner." And at the present day the colonial churches are entirely free in this matter. This, however, is not the case with the church in India. Here the bishops of sees founded down to 1879 receive a stipend from the revenue (with the exception of the bishop of Ceylon, who no longer does so). They are not only nominated by the Crown and consecrated under letters patent, but the appointment is expressly subjected "to such power of revocation and recall as is by law vested" in the Crown; and when additional oversight was necessary for the church in Tinnevelly, it could only be secured by the consecration of two assistant bishops, who worked under a commission from the archbishop of Canterbury which was to expire on the death of the bishop of Madras. Since then, however, new sees have been founded which are under no such restrictions; by the creation of dioceses either in native states (Travancore and Cochin), or out of the existing dioceses (Chota Nagpur, Lucknow, &c.). In the latter case there is no *legal* subdivision of the older diocese, the new bishop administering such districts as belonged to it under commission from its bishop, provision being made, however, that in all matters ecclesiastical there shall be no appeal but to the metropolitan of India. But this is an obvious anomaly, and it is likely that matters will be simplified in the future.

Spiritual autonomy.

(3) By degrees, also, the relations of colonial churches to the archbishop of Canterbury have changed. It was at first assumed, as has been said, that a colonial bishop was an extra-territorial suffragan of the archbishop. Until 1855 no colonial bishop was consecrated outside the British Isles, the first instance being Dr MacDougall of Labuan, consecrated in India under a commission from the archbishop of Canterbury; and until 1874 it was held to be unlawful for a bishop to be consecrated in England without taking the suffragan's oath of due obedience. This necessity was removed by the Colonial Clergy Act of 1874 (37 and 38 Vict. c. 77, sec. 12), which permits the archbishop at his discretion to dispense with the oath. This, however, has not been done in all cases; and as late as 1890 it was taken by the metropolitan of Sydney at his consecration. But natural as it is that the oath should be taken by a colonial bishop holding mission from the archbishop of Canterbury, that it should be taken by the suffragan of another province, or still more by a metropolitan, is an obvious anomaly, and one which will doubtless be modified in course of time. Thus the constituent parts of the Anglican communion gradually acquire autonomy: missionary jurisdictions develop into organized dioceses, and dioceses are grouped into provinces with canons of their own. But the most complete autonomy does not involve isolation. The churches are in full communion with one another, and act together in many ways; missionary jurisdictions and dioceses are mapped out by common arrangement, and even transferred if it seems advisable: *e.g.*, the diocese Honolulu (Hawaii), hitherto under the jurisdiction of the archbishop of Canterbury, was transferred in 1900 to the church of the United States on account of political changes. There is a strong affection for and deference to the see of Canterbury, which shows itself by frequent consultation and interchange of greetings; there is also a strong common life which has been emphasized in recent years by common action (LAMBETH CONFERENCES), and seems likely to be even more significant in the future.

The Anglican Communion consists of the following: (1) The Church of England, 2 provinces, Canterbury and York, with 23 and 10 dioceses respectively. (2) The Church of Ireland, 2 provinces, Armagh and Dublin, with 7 and 6 dioceses respectively. (3) The Scottish Episcopal Church, with 7 dioceses. (4) The Protestant Episcopal Church of the United States, with 81 dioceses and missionary jurisdictions, including North Tokyo, Kyoto, Shanghai, Cape Palmas, and the independent dioceses of Hayti and Brazil. (5) The Canadian Church, consisting of (*a*) the province of Canada, with 10 dioceses; (*b*) the province of Rupert Land, with 8 dioceses, of which 2, Saskatchewan and Calgary, are at present united. (6) The Church in India and Ceylon, 1 province of 11 dioceses. (7) The Church of the West Indies, 1 province of 8 dioceses, of which Barbadoes and the Windward Islands are at present united. (8) The Australian Church, 1 province of 6 dioceses and 9 (at present) unorganized dioceses, which, however, are united under the General Synod of Australia. (9) The Church of New Zealand, 1 province of 6 dioceses, together with the missionary jurisdiction of Melanesia. (10) The South African Church, 1 province of 10 dioceses, with the 2 missionary jurisdictions of Mashonaland and Lebombo. (11) Nearly 30 isolated dioceses and missionary jurisdictions holding mission from the see of Canterbury.

AUTHORITIES.—*Official Year-book of the Church of England.*—PHILLIMORE. *Ecclesiastical Law*, vol. ii. London, 1895.—*Digest of S.P.G. Records.* London, 1893.—E. STOCK. *History of the Church Missionary Society.* 3 vols. London, 1899.—H. W. TUCKER. *The English Church in Other Lands.* London, 1886.—A. T. WIRGMAN. *The Church and the Civil Power.* London, 1893.
(W. E. Co.)

Anglican Orders.—The attacks which Roman Catholic controversy has made upon the orders of the English Church have varied greatly in character, and shifted their ground from time to time; but all may be reduced to two classes: (i.) historical objections, and (ii.) ecclesiastical objections.

(i.) The difficulty began with the repudiation of papal supremacy by Henry VIII., when, according to Roman theory, the English Church became schismatical and its orders marred by the taint of schism. A further alienation took place when the Edwardine English ordinal of 1550 and 1552 superseded the old Latin pontifical, and orders were thereupon conferred by a newly-reformed rite. At Mary's accession the pontifical was restored, and eventually Cardinal Pole reconciled the English Church with the Holy See. The exact effect of his action is a matter of controversy. There is no question that he reconciled the schism to the Pope's satisfaction, and therefore that objection to the Henrician and Edwardine orders came to an end; but it is a disputed question both how he was authorized by his papal faculties to deal with the orders conferred by the Prayer Book rite and, also, how in fact he did deal with them. Historical inquiry shows that for a short period before Pole's advent a small number of reordinations took place, but subsequently they almost entirely ceased; and it is contended that in other cases the orders were tacitly allowed, possibly after some slight supplemental ceremony, and that Pole's instructions were designedly vague. The contention is supported by the fact that, while a vast number of parochial clergy were deprived in 1553-54, no case is known of a deprivation on the ground of Edwardine orders. In answer to this Anglican contention an attempt is made to extract from Pole's instructions a definite condemnation of the Edwardine orders, and to maintain that all such clergy as were allowed to minister in Mary's reign must have been reordained. When the Prayer Book was restored under Elizabeth the question returned again, and there is no doubt that since the latter half of the 16th century the Roman Catholics have continually treated Anglican orders as null and void. Still there was no adverse decision. The orders were vaguely attacked, and after 1570 reordinations took place abroad, and in 1608 at Rome; but there was little definite justification offered for this till the Nag's Head fable was invented in 1604, and it was seriously maintained that Archbishop Parker—the main channel of Elizabethan orders—had had no better consecration than a mock ceremony in a tavern. This fable has had great influence on the controversy. In 1616 doubts were cast on the consecration of Barlow, Parker's chief consecrator. There was more justification for this, but both these historical objections have broken down. They were not, as it now appears, seriously entertained at the first official inquiries into the question at Rome in 1685 and 1704; and though they survived until recently as large factors in popular controversy, they bid fair now to disappear, and the battle is shifted to other ground.

(ii.) The theological or ecclesiastical objections fall into three classes. First and earliest came the objection to the orders on the ground of the repudiation by the English Church of the theory of papal supremacy. This has figured largely in the earlier and the less scientific phases of the controversy; but, accurately speaking, it is no objection to the validity but only to the regularity of the orders, and it merely forms part of the general subject of the relation of the English Church to the Papacy, and affects Anglican orders on the same ground as the orders of the Orthodox Church. The other two points touch the question of the ordinal in English, which in 1550 took the place of the old English pontificals in Latin, and with slight modifications remains the ordinal of the Anglican communion to-day. Objection is raised to this on the ground: (a) that it is, in "form," deficient in the essentials required for a valid ordination; and (β) that the "intention," which lies behind it, and with which the Church uses it, is also deficient. (a) The criticism of the "form" of the ordinal has taken many shapes, and several charges have been made, only to be withdrawn as inadmissible. It has been maintained that the mere giving up of the Latin pontifical was in itself a final departure from the "form of the Church": but the Church Catholic has no one single form for holy order; it has used, and still uses, many forms. The absence of any "porrection of instruments" after 1552 has been made a grave objection, because Eugenius IV. defined this (1439) to be the essential matter of ordination. But his definition was never universally accepted, and since the work of Père Morin (1686) has been recognized to be erroneous. Other and more subtle objections to the Anglican form have been raised ever since the question was first officially examined at Rome in 1685, and again for the Gordon Case in 1704. The documents of these two inquiries have been only recently and incompletely published, and the precise nature of the objections raised is not clear. But they were probably the same as those raised in the bull *Apostolicæ Curæ* in 1896, viz., that the words accompanying the imposition of hands are an insufficient form to define the action which is going on. Attention is called to the fact that the words were made more explicit (both for priests and bishops) at the revision of the Prayer Book in 1661. To this it is replied: that the alteration was made to refute a Presbyterian construction of the forms; that the defining is at least as clear as in the Roman rite, where no words at all necessarily accompany the imposition of hands; that the whole service defines beyond any doubt what the action is, and what the order is that is being conferred; and that the mere imperative formulæ of 1550 do in fact define the order in Biblical terms, and are more explicit than some of the early ordination prayers, which do not define at all. All these objections as to "form" are comparatively modern, for the English ordinal was used in Edward's time by some of the Marian bishops; and even according to the most modern papal interpretation of Pole's instructions it would seem that orders conferred by them using this form were to be held valid, *i.e.*, the form was in itself not insufficient. The Roman attack is thus inconsistent with itself, as well as with the Roman rite and the history of Roman ordinations. (β) The question of intention is raised partly as a general objection, and partly with reference to the actual ordinal and the Anglican doctrine of orders. To the general objection that unsoundness of views invalidates the ordinations, it is replied—first, that this is not true of individual views, but that the intention to be taken into account is the intention of the Church; and, secondly, that the general intention of the English Church with regard to orders is expressed in the preface to the ordinal as an intention to continue in valid sequence the orders that have been in the Church since apostolic times, and is therefore unexceptionable. Further, the special objection is raised that the English Church fails to express the intention in the case of the priesthood, because it makes no special mention at the ordination of the power of offering sacrifice. To this it is replied that—first, such mention is only a mediæval addition to the Latin pontifical, and therefore is unessential; and, secondly, the ordinal mentions the whole work of the priesthood, and not only one side of it, and thus expresses a more comprehensive and fuller intention than the Latin pontifical.

The controversy is thus still undecided. The Roman decision has not met with full approval from learned men in that communion, and has been repudiated not only by Anglican but by Orthodox writers.

The elder phases of the controversy have been superseded by recent action at Rome and in England. The older books which still are valuable are two:—On the Roman side—Estcourt, *Question of Anglican Ordinations*, 1898; on the English side—Denny and Lacey, *De Hierarchia Anglicana*, 1895, and *Supplement*, 1896. The latest phase begins with the publication of the bull *Apostolicæ Curæ*, Rome, 1896. The principal pamphlets and books are:—On the Roman side—*A Vindication of the Bull*, by the Roman Catholic bishops, 1898; Brandi, *Roma e Canterbury*, Rome, 1897: on the English side—*The Answer of the Archbishops of England*, 1897; *A Treatise on the Bull*, 1898; and *Priesthood in the English Church*, 1898; A. Bulgakoff, *Question of Anglican Orders*, 1899. These three are tracts xix., xii., and liv. of the *Church Historical Society*. Also, A. Lowndes, *Vindication of Anglican Orders*, 2 vols. New York, 1897, is a useful general summary.

(W. H. F.)

Angling.—Strictly speaking, angling should mean the capture of fish with the hook, as distinguished from netting, spearing, or trapping; for "angle" is an old English word applied to the hook, which in very ancient times appears to have been made in angular form. Such angular hooks are still used by the natives in tropical seas. In modern times, however, angling is the term used to denote the various forms of fishing, recognized as sportsmanlike, with rod, line, and hook.

Fly-taking fish.

Coarse fish.

The principal British fishes which are sought after by the sportsman naturally divide themselves into two classes. In the first class are the members of the salmon family which yield sport to the fly-fisher; namely the salmon itself, the sea-trout, the brown trout, and the grayling. To these may perhaps be added the char; but this very delicate and highly esteemed fish, in English waters at any rate, rises badly, and is not often caught except on spinning baits fished at a considerable depth. In Scandinavia, on the other hand, it rises exceedingly well in many lakes, and grows to a large size. The smelt is also a member of the salmon family, and ascends rivers to spawn, but it can hardly be reckoned among the sportsman's fish. The second class are commonly spoken of as "coarse fish," and include those species which are found in most of our rivers, lakes, and ponds. They are the pike, barbel, bream, perch, carp, tench, chub, roach, rudd, dace, and gudgeon. Of these, chub, dace, and rudd yield sport to the fly-fisher, and, in certain waters, roach and even perch will take a fly freely in the summer time. Instances are recorded from time to time of other coarse fish taking flies, but, generally speaking, they are fished for with natural baits of various kinds. Perch, while not despising such baits as worms, feed more particularly on the young of other fish; while the fish of the carp family, which includes the roach, rudd, dace, chub, barbel, bream, tench, and gudgeon, feed mainly on vegetable growths, worms, water insects, and sundry pastes when proffered by the angler, and are usually captured on float or leger tackle, by the process known as bottom-fishing. Pike, on the other hand, are fished for with natural or artificial baits kept in movement a few feet from the bottom if dead, while live baits are usually suspended by a float, or used by means of the paternoster or leger methods, which will be described later.

Salmon.

Returning now to the game fish; the salmon first of all claims our attention by reason of its size, sporting qualities, and excellence as food. This fish is rapidly disappearing from the rivers of England and Wales, and has seriously diminished in numbers in most of the rivers of Scotland and Ireland. The primary cause of the decrease of salmon is undoubtedly the increase of the population in the British Isles generally, which demands such an increased fish supply that the salmon, which fetches high prices, is eagerly sought after by professional fishermen and others for the market. The demand is, in consequence, largely in excess of the natural supply; and the natural supply itself is diminished in many cases by pollution which destroys the eggs of the salmon, by manufacturers' turbines, water-wheels, and other apparatus which destroy the young of the salmon and hinder the travels of the spawning fish up stream; and by the capture by poachers of the large salmon themselves when on the spawning beds. In the sea, in the estuaries of rivers, and even in the narrow freshwater rivers themselves, salmon are ruthlessly netted for market purposes. It is a striking peculiarity of the salmon that while it must, in view of its rapid growth, feed largely in the sea, it is rarely caught in salt water by the angler. In rivers, on the other hand, where it rises to the angler's fly and takes his prawn, worm, gudgeon, or other bait, it rapidly gets out of condition and is believed to feed but little. In most salmon rivers there is, as a matter of fact, little food to sustain such large fish. The most sportsmanlike method of catching salmon is undoubtedly with the fly, though, generally speaking, the combination of feathers, tinsel and wools which go to make up this lure, does not represent any insect known to entomologists. What are termed fancy flies are possibly taken by the fish for the young of some marine creature, or simply for some unknown thing struggling to escape. To the present day trout are fished for in Norway with a piece of red rag trailed behind a boat, and it can hardly be suggested that the fish regard this as any known item of food, or that it is absolutely necessary that artificial flies or baits should represent existing insect or animal life. Grilse, which is the name given to salmon on their first return to the river before spawning, will rise to such flies as the March brown; and even a full-grown salmon will occasionally take quite a small fly. Salmon rise most readily when first leaving the sea and entering the river. After being in fresh water a little time they apparently settle down to a period of inactivity and feed badly, though a rise of water will generally set them moving upwards, and on reaching a new pool they may often be induced to rise. It should be mentioned here that in some rivers salmon are running up from the sea all the year round; and it is one of the problems connected with this remarkable fish to explain why, in the Tay, for instance, it should enter the river in January, seeing that the principal purpose for which it comes into fresh water, namely spawning, is not carried out until the following autumn at the earliest. These January fish, moreover, have apparently not spawned during the months preceding their entry into the river, and unless it is assumed that they are all barren fish, which is unlikely, it would appear that the salmon or some members of the species do not spawn every year. In the majority of salmon rivers there is a spring run of salmon; in July and August shoals of grilse enter the river; while in September there is the autumn run of big fish, which have evidently come up for spawning and no other purpose. About the beginning of September, netting, as a rule ceases, the dates varying in different rivers; but angling with rod and line is still allowed for a few weeks, as otherwise the proprietors of the upper reaches of the river, who protect the salmon on the spawning beds, would obtain no sport at all. In November angling entirely ceases, and the salmon soon go on the gravelly shallows, where the female deposits her eggs, a few of them only being vivified by milt from the male. The fish cover their eggs by sweeping gravel over them. In the course of a few weeks the eggs hatch, and the resulting fry remain in the river about two years, very much resembling the small trout in appearance.

They then begin to grow silvery, descend to the sea herring-size, and return weighing from 3 lb to as much as 14 lb. The salmon on its first return to the river is termed grilse, as we have said; but in Ireland the corresponding name is peal, which should be distinguished from the same word used in the west country, where it is always applied to sea-trout. The capture of the smolts is illegal, but a good many are killed in mistake for trout.

Fly-fishing for salmon.

There is an endless variety of flies used for salmon fishing, but the angler need not supply himself with a very great variety, so long as he is provided with flies of various sizes, as size is regarded, by experienced salmon fishermen, as being even more important than colour. Speaking generally, the flies used in early spring are large, and they diminish in size as the season grows older. In autumn quite small flies are used for the fish which have been some time in the river, and, as a general rule, the lower the water, the smaller should be the fly used, and the deeper should it be fished. For very bright weather and clear water, lightly dressed flies, which are mainly light yellow in colour, are standard favourites, such as the Sun-fly and the Mystery. But undoubtedly the most generally favoured of all the salmon flies, and one which can be reasonably relied upon to kill, if dressed of the right size, and if the salmon are in taking humour, is the Jock Scott. It perhaps owes its reputation largely to the fact that it is a particularly suitable fly for use when the rivers are clearing after a spate; and as this is quite the best time for salmon fishing with the fly, the Jock Scott, as a result, kills perhaps more fish than any other fly known to anglers. The tackle of the salmon fly-fisher is simple, but somewhat expensive, as the fish are so strong, and of such value when captured, that to use weak or indifferent tackle is properly regarded as a foolish proceeding. The rod itself may vary in length from 12 feet to 18 feet, according to the strength and height of the user, and is usually made of either split cane, with or without a steel centre, or of greenheart. It should have plenty of wood in the top joint, to give it lifting power. It should bend right away down to the butt when the cast is made, but must on no account be weak in the middle, for the salmon fisher sometimes has to refuse the fish even an inch of line, which places an enormous strain upon the rod. The line is usually of plaited silk, and waterproofed, with an oil dressing. It should be what is termed solid, that is, not plaited round a core, nor with a centre left hollow. At the end of the line comes the 3 yards of strong salmon gut, the upper part of which may be twisted or plaited, and then the fly. In big, fast-running rivers, treble or double gut is sometimes required right down to the fly. Salmon flies are now very commonly tied on eyed hooks, but many salmon fishers believe that they swim better if there is simply a small gut loop whipped on at the end of the shank. To the eye or the loop is tied a short length of gut which, in its turn, is looped on to the cast. There are many kinds of excellent salmon reels made in England, the mechanism of which varies. The angler should see that there is a good strong check, and that the reel itself is strongly made and durable.

In working the salmon fly, the angler fishes either from a boat or from the bank, according to the river, and casts over pools and other places which are known by experience to be frequented by salmon. As a rule, only one fly is used, and the cast is made across and a little down stream, the current bringing the fly round, when the fly is drawn up stream a little and a fresh cast is made. When grilse are in the river two flies are often used, particularly if the fish run small; and in some pools the flies are cast up stream and drawn quickly down or across, the dropper fly being worked along the surface. There are many rules which are firmly believed in by old salmon fishers, but the salmon are constantly breaking them; as, for instance, by taking a fly floating on the surface, and by rising in pools where, according to local tradition, salmon are never caught. The height of the water has a very great deal to do with success in salmon fishing, and while, at a certain level, certain pools will hold rising fish, if the water falls or rises a little these pools may become useless, and other pools come into play. In big rivers the salmon fly is often harled, that is to say, allowed to trail out behind a boat which is rowed backwards and forwards across the stream, being dropped a few yards at each crossing. By this means the fish sees the fly before being alarmed by the boat passing over it. In lakes salmon are usually fished for with two flies, the dropper being worked along the surface. Both in lakes and rivers, the angler who fishes the hardest, other things being equal, generally succeeds the best; and it must not be supposed that the fish will not rise because the pool has been fished over two or three times. Sooner or later the psychological moment arrives and the salmon rises. When a salmon misses the fly it is good policy to rest him for two or three minutes and then fish for him again, starting a little above him and gradually working down. If he again misses the fly, a smaller size of the same pattern may be tried, and a still smaller one if he rises and misses this. Then other patterns may be tried if necessary. In playing the salmon the rod should be kept well up, with the butt resting against the hip and the left hand grasping the rod a little above the reel. The line should not be touched by the left hand. The right hand should be kept on the handle of the reel, and the line should be wound up at every opportunity, if only a few inches, and allowed to run off the reel if the salmon makes rushes or heavy plunges. The angler should follow the fish, running or walking, as far as the bank will allow, and never give an inch more line than he is obliged to, of course having due regard to the strength of the tackle. If it can be done without bringing the fish into a dangerous position, the salmon should be worked down stream. Thus the angler when playing a salmon maintains a position on the bank a little below the fish if he can. It is an almost impossible thing to draw a very heavy fish up stream against a strong current. A very sulky fish may be handplayed. Salmon are also fished for with various baits, such as the prawn, worm, minnow, stone loach, gudgeon, and artificial spinning baits of which the phantom and spoon are the best. The spinning baits are usually harled in large rivers. The prawn is, as a rule, cast out and allowed to float down stream at about mid-water, but sometimes it is harled. It is a deadly bait in clear water. A bunch of worms is used in thick water, while a single worm on two-hook tackle may be cast up stream in low clear water.

Trout.

Trout, which most modern authorities consider spring from a common ancestor, vary remarkably in size and appearance. In a Devonshire brook they may average a fifth of a pound, while in lakes they grow to over 20 lb. The Thames grows the largest in England. One was caught in Loch Stennes which weighed 29 lb. A cast of this remarkable fish is preserved in the smoking-room of the Fly-fishers' Club, London. Trout may be divided broadly into two kinds: those which live permanently in river or lake, and those which pass the greater portion of their lives in the sea, visiting the rivers in summer and autumn, and while there pro-

Sea-trout.

pagating their species in much the same manner as the salmon. Sea-trout (*Salmo trutta*), sometimes called salmon-trout, and known in Ireland as white trout, of which the bull-trout is a variety, afford sport of the highest class to the fly-fisher. They are found in many salmon rivers and smaller streams, and exhibit a partiality for lakes connected with the sea. They are caught both in the tidal portions of the rivers, and in the upper reaches. Fly-fishing for them is carried on in almost identically the same manner as what is termed wet-fly fishing for brown trout; except where the fish run, large and small salmon flies are used, in which case the flies are cast and worked much as they would be for salmon. Sea-trout are notorious short risers, and both for these and for salmon which have been some time in the river and rise warily, a long-shanked double hook, small in the bend, is now largely used. It is known as the Bickerdyke "Salmo irritans" hook, *Salmo irritans* being a name humorously conferred upon the fish which just touch the fly without being hooked. Sea-trout are found in the pools of rivers, in small eddies, and generally in many of the places favoured by brown trout; but they show a great partiality for a long rippling run of a few feet in depth, while in the tidal portions of a river a shoal will frequently be found collected round a sandy spit in only a foot or two of water. They are generally fished for with rather gaudy flies with a mixed wing, the body composed of mixed seal's fur (such as olive with a little crimson and blue), with a ribbing of flat silver tinsel and a short red tuft at the tail like the Zulu. They will at times take all the ordinary brown trout and loch flies such as are used both on river and lake, and in tidal pools there are few better flies than a silver-doctor tied exceedingly small, while small Alexandras are also killing. The angler should be guided as to the size of his fly by the nature of the water, in a heavy stream a larger fly being used than in a quiet one; while in the pools, if there is a good ripple, a slightly larger fly should be used than if the ripple is trifling. In lakes, sea-trout are found scattered over all the shallower portions, but favourite spots will be round the edges of weeds and at the inlet and outlet of a stream. Sea-trout will take small spinning baits and worms, and are often fished for with a worm used on spinning tackle. A favourite artificial bait on the east coast rivers of Scotland is a very small tube of india-rubber threaded on a hook, and cast by means of the fly rod.

Non-migratory trout.

So far as fly-fishing is concerned, the non-migratory trout are angled for by two very distinct and characteristic methods. On most of the English south-country rivers, and in not a few of those in the Midlands and farther north, the various flies of the Ephemeridæ family are very abundant, and as they come floating down the river the trout rise to the surface, take up a position, and seize fly after fly. To capture the trout in such circumstances the dry-fly method of fishing has been invented. The flies resemble the natural insect, are tied with cocks' hackles which are somewhat stiff, and are frequently moistened with paraffin to make them float. A single fly is used; the line, a heavy and tapered one, is greased; and the rod is usually a short but powerful weapon of about 10 feet in length. A feeding fish having been marked down, the angler stalks him very carefully, keeping well below him, and casting the fly with great precision about a yard above him so that it floats down over his nose, when the trout may or may not take it. Dry-fly fishing has become exceedingly popular of late years and has many enthusiastic professors. Though imitations of the Ephemeridæ are most generally used, sedges, alders, palmers, and other flies find places in the dry-fly fisher's book; and when the spring fishing is over most of the trout are caught in the evening by means of sedges of various kinds. In wet-fly fishing the angler regards wind as a necessity on the more quiet pools, but in dry-fly fishing the trout are caught in absolutely calm water. The secrets of success lie, firstly, in being able to mark down feeding fish; in selecting those which are under the bank rather than out in the middle; in keeping within casting distance of the fish without being observed; in choosing the right fly, and casting with precision. The difficulties of capturing fish depend very largely on the amount of fishing done in any particular river. If, for instance, it is a club water which is heavily fished, and large numbers of small trout are constantly being returned, the fish become exceedingly shy and difficult of capture; and it is quite possible that a certain proportion of them, finding surface feeding a dangerous amusement, turn their attention to the vast wealth of crustacean and other natural food which is found among the weeds of the chalk streams. Among the flies which are general favourites with dry-fly fishers are the blue dun, red or claret quill, medium olive quill, iron blue, dark olive dun, gold-ribbed hare's ear, silver sedge, orange sedge, cinnamon quill, little marryat, pale olive quill, detached badger, alder, Wickham's fancy, pink Wickham, and the May-fly.

Dry-fly fishing.

Wet-fly fishing.

Wet-fly fishing is more particularly appropriate to streams where there is no considerable amount of surface food, where the water is shallow and of a broken character. Here the trout are ever on the look-out for passing particles of food, and the angler walks up stream casting one, two, or three flies ahead of him, allowing them to drift back with the current and striking if he perceives the least check of the line. On some big rivers, where the water is coloured, it is a common practice to fish down stream with a long line, but the up stream method is generally the most successful. Even in low water, on hot, bright, sunny days, a basket of fish may be made by wading up stream, using a single fly, casting it in little runs behind rocks and stones and in every nook and cranny likely to hold trout; and it is astonishing to find what very small places will hold trout of a very respectable size. In such circumstances down stream fishing would be absolutely useless. For the trout of the smaller English, Irish, and Welsh rivers, and the Scottish burns, very fine tackle should be used, and, within reasonable limits, the lighter the rod the better, for it allows of more delicate manipulation. The trout run small, rarely exceeding half a pound, but the fishing, when there are several miles of breezy moorlands to be walked, is of a very delightful character, and the charm of the surroundings and the healthiness of the exercise will fully compensate for the lack of weight on the part of the quarry. There are some streams which possess the characteristics of both wet-fly and dry-fly waters; such, for instance, is the Dove. Here there are many quiet reaches of no great depth where there is an abundance of surface food, and the dry-fly fisher can pass many happy and profitable hours; while between them there are long rippling shallows, swirling eddies, and miniature falls, where the wet-fly fisher has every opportunity of killing fish with his own particular method. To fish such a river it is desirable that the angler should be acquainted with both methods, using each in its appropriate place. In fact, an angler can hardly be said to be a finished fly-fisher until he is as expert with the dry fly as he is with the wet fly. It is impossible here to give a complete list of the flies used by trout fishermen, but among the general favourites are the red and black palmers, coch-y-bondhu, black gnats, the governor, the coachman, duns of various colours, Greenwell's glory, March brown, redspinner, alder, &c. For wet-fly fishing the fly should, as a rule, be sparsely dressed, and the hackles should be soft. For low, bright water, where the fish are at all educated, some of the very best flies are those used on Yorkshire streams. But now and again one happens upon a river where the trout show a decided preference for big heavily-dressed flies. In common language, they appear to like a big mouthful.

May-fly fishing.

Fishing with the May-fly is a thing of itself. On some rivers these large species of the Ephemeridæ rise in extraordinary quantities, and the trout take them very freely; in fact, in rivers containing coarse fish the trout generally run large, and, as a general rule, refuse the fly at any other time. The big rise of May-fly, however, tempts them to the surface, and a goodly number are captured during the first week or two of June. Like the duns, the May-fly is fished either wet or dry, but more often dry than wet. It sometimes happens, however, that the wet fly will kill better than the dry. As the fly goes through its various changes the artificial should be altered to correspond to it. First we have the greendrake; then this sheds its skin and becomes the greydrake; and, lastly, the greydrake dies and floats down with wings expanded on the water, when it is known as the spent gnat. The fly-fishing on a river is usually rather poor for a week before the May-fly appears and for a week or two after it has disappeared, and by some anglers the presence of the fly is on this account objected to. On the other hand, the May-fly has a splendid feeding effect on the trout, putting them into finest possible condition.

Lake trout.

Lake trout, except where there is an abundance of coarse fish or bottom-feeding, generally rise much better to the fly than river trout, and are usually captured when there is a breeze to ripple the water, and the day is not too bright. The fish lie round islands, off rocky points, by the sides of weeds, and over shallow ground generally, but are not much fished for with the fly in the deeper portions unless there is a rise of May-fly or other insects to bring them to the surface. The common practice is to row the boat to windward of some likely spot, then drift over it. The anglers, if there are two, sit at each end of the boat and take alternate casts. Short casts are better than long ones, for the trout will rise close to the boat, and it is, generally speaking, important to let at least one of the flies drag along the surface of the water. When a fish rises at the fly and misses it, he should be cast over again instantly, and may often be caught. Indeed, the writer has on more than one occasion known a fish to rise in front of the boat, miss the fly, the boat go over the fish, and the angler to take a cast behind the boat and secure the trout. Some lakes are not suited for drifting, and it is better for the attendant to row the boat, putting it near likely spots for fish. One great point in successful loch-fishing is to let the wind work the flies as much as possible. This can only be accomplished with rather a long rod, 12 feet or 13 feet being a good length. The line is cast out sideways, and the wind, bearing out the line, drags the flies in the same direction as the boat is drifting. By this means the flies are given the natural motion of drifting with the wind. When they are drawn against the wind the motion is unnatural, and a large fish will often refuse to take them. The flies used in lake fishing are mostly of a fancy character, lake trout showing considerable taste in the matter of colour, to which, in Ireland particularly, great importance is attached. There pigs' wools and silks, furs of various hues, including olives, russets, reds, browns, &c., are used, either alone or mixed. The usual wing is cut from the breast feather of a mallard, and the hackle, red or black. A fly tied with red body and teal wing is a standing favourite. Large lake trout often show a preference for a claret-bodied fly with a dark mallard wing and black hackle. The size of fly used should vary according to the wave or ripple, and whether the day is bright or otherwise. The rougher and darker the day, the larger and darker the fly. On a bright day, with a small ripple, small brightly-coloured flies should be used. Different lakes, however, have their own peculiarities, and if there is a rise of any particular fly on a lake, that fly should of course be imitated. The moorlands have peculiar flies of their own, and on lakes situated among them, imitations of those flies should, if possible, be used. On several of the big Irish lakes there is a considerable rise of May-fly, when the fish will take the artificial, but are more readily caught with the natural insect, one or two of which are impaled on a No. 6 or No. 7 hook and allowed to drift along the surface, the tackle being simply 2 feet of fine gut, above which is about 10 yards of floss silk, and then a fine running line. With a fair breeze the floss silk can be dispensed with, and an ordinary twisted silk, undressed line used. The most expert lake dappers prefer a short line to a long one. In a very faint air trout may sometimes be caught in this way by tying a goose's breast feather into the floss silk line about 4 feet above the hook. By this means, if the rod is a long one, the May-flies can be got out sufficiently far to secure an occasional rise.

Bait fishing for trout.

In addition to the fly, the two other most common methods of catching trout are with a natural or artificial spinning bait, and with the worm. The most sportsmanlike of these, in the sense that it requires most skill, is what is termed clear-water fishing with the worm. On three small hooks, placed at short intervals at the end of the cast, and commonly known as Stewart tackle, is impaled a well-scoured red worm, and this, when the water is low and bright, the angler casts, wading up stream and fishing every hole and corner in much the same manner as is already recommended for the single fly, used under similar conditions. Grilse and sea-trout are also caught in this way, and occasionally a salmon. The difficulty, of course, is to cast or swing out the bait without causing it to break away from the hooks. The worming, which is done when the river is in flood, is of a very different character. Here a piece of lead is fixed on the line above a good-sized hook, and a big worm is let down in eddies close to the bank, where sooner or later a fish takes it. Minnows, which may be either imitations such as the phantom or Devon, or the natural minnow fresh from the stream, or one which has been preserved in formalin or other preservative, are cast across the stream, the line being drawn rapidly in towards the angler. About 3 yards of gut is desirable above the bait, and at least 2 yards from the minnow should be placed a very small lead, immediately below which is a double swivel. It is important that the lead should hang a little below the level of the line to prevent it from twisting. This ensures all the spinning taking place below the lead and the swivels doing their duty. A considerably stiffer rod is required for this method than for fly-fishing, as much more pressure is required to get the triangles which are used into the trout than the single hook on which the fly is mounted. In the Thames bleak and small dace are used for spinning, and it is a common practice to use live bait for the larger trout which in that river approximate in size to salmon. The Thames live-bait tackle is extremely simple. It consists merely of a very small cork, nothing being better than that taken from a chemist's vial, with a slit down it in which the line is placed. A yard and a half below this are three or four

Thames trouting.

No. 1 shot, and a yard and a half below the shot a lip hook and a small triangle. It will be seen that the bait plays near the surface, for near the surface are the trout when feeding. Success largely depends on knowing the whereabouts of the fish. Many trout take up their position after early spring in the more quiet reaches of the river, but most of the fishing is done in the weir-pools and on the shallows below them.

In lakes, spinning is usually termed trolling, and is commonly carried on by trailing the bait some distance behind the boat. In this case, as there is no casting to be done, the lead should be placed as far as possible from the bait; one of the best tackles for the purpose is a small Chapman spinner. Large trout which are never caught with the fly, except in the May-fly season, may be caught by trolling. They are, as a rule, on the shallows in March and April; about June they begin to move into deeper water and remain there until September, when they are found round the months of tributary rivers and streams up which they will by and by run for spawning. The deep waters of lakes are not sufficiently fished, perhaps because the labour of working them properly is considerable. As much as a pound of lead may be required to get down to the depths where the big fish lurk, and so that this lead may not alarm the wary old trout it has to be placed not less than 12 feet from the bait. Among the best baits used are small trout, minnows, gudgeon, bleak, and stone loach (called collochs in Ireland). A fish firmly believed in by many Scottish loch-fishers is *Salmo ferox*, which is caught usually by trolling. It is, as a rule, a big-headed, ugly, dark old fish, and modern ichthyologists are of opinion that it is simply a lake trout of considerable age and usually a male. Trout vary so much in appearance, according to their age, sex, food, and the nature of the soil over which they swim, and other local conditions, that many alleged species have from time to time been discovered, which, in the end, turned out to be simply local varieties of the ordinary brown trout.

Rainbow trout.

Rainbow trout (*Salmo irideus*) have now been so largely introduced into England, that they certainly claim attention. As regards their beauty, sport-giving and edible qualities, they rival the sea-trout, while they grow with astonishing rapidity when well furnished with food. They are easily reared, and are certainly a great acquisition. They have not yet had time to become acquainted with the methods of English fly-fishers, and rise freely at any fly and take all the ordinary trout baits. They succeed particularly well in lochs and other enclosed sheets of water. They appear to have migratory tendencies, but it has not yet been definitely ascertained whether this migration is simply in search of food from streams and rivers where they find themselves starved, or whether it is an instinct. A quantity which were placed in the Dove have, to the knowledge of the writer, remained there three years. They have disappeared from many streams.

Grayling.

The grayling (*Salmo thymallus*), which is found in many of the trout streams, is, like the trout, a member of the salmon family. It spawns in the spring, gets rapidly into condition, but is more commonly fished for in autumn than in summer. On the whole, it frequents somewhat quieter waters than the trout. In the chalk streams it is taken by the ordinary dry-fly methods, and elsewhere with both the wet and dry fly. It is less easily alarmed than the trout, and will rise again and again from the bottom, a peculiarity of the fish. Two of the best grayling flies are a very small apple-green dun and the red tag; but a good imitation of any fly on the water will usually take this fish. Many grayling are caught in the north of England by means of light worm tackle worked with an exceedingly small float and a single shot. This is cast out here and there in rippling streams, the angler striking at the slightest bite. A method which is gradually dying out is the so-called grasshopper, a good-sized hook weighted with lead and the shank bound round with green silk, a straw placed on each side of the bend of the hook, and the point covered with gentles. This arrangement is worked with a sink-and-draw motion, and can hardly be termed a sportsmanlike method, for the grayling is a very sport-giving fish.

Pike.

Pike, or jack (*Esox lucius*) are usually fished for with a dead or live bait, according to the season of the year and the condition of the water. When the weeds are down, or at any time in such places as weir-pools, a live bait on float tackle is a deadly method, provided the bait can be made to travel, and be brought under the observation of a number of fish. For very small baits a single hook is used, placed through the lip of the bait. For those of medium size, two triangles, placed within about an inch and a half of each other, are preferred. The hook of the upper of these is caught in the back fin of the bait, while the hook of the lower triangle, usually made small for the purpose, and sometimes reversed, is affixed to the bait near the shoulder. This is commonly known as the Jardine tackle. For larger baits the Bickerdyke tackle is one of the best made. This is saddle-back in character, arming both sides of the bait. A single hook is stuck through the back fin and whipped on to the two links of gimp bearing the side hooks, where they join. One of these side triangles hangs down loosely under the back fin, while the other, which is on a longer piece of gimp, is brought up to the shoulder of the bait and held there by means of a reversed hook. Thus, when a pike is struck the tackle is usually pulled away from the bait into the fish's mouth. Live baiting with gorge tackle is quite out of date, snap tackles of the kind described having proved far more effective. Paternostering is another method of pike fishing with live bait much favoured by modern anglers. The pike paternoster consists simply of a two-yard length of stout gut, at the end of which is a half-ounce weight, bullet- or pear-shaped. About two feet from the weight a loop is tied in the gut, and to this is looped a short length of gimp which bears the hook. A long, rather light bamboo rod should be used for swinging out this tackle. The angler fishes entirely by feel; drops his bait in likely places, and, on getting a run, should strike without delay. Spinning is regarded as one of the most sportsmanlike methods of taking pike, and, particularly in lakes, is one of the most successful. The best method of mounting the bait is either on a Bromley-Pennell flight or a Chapman spinner, and the bait may be a small dace, gudgeon, bleak, or sprat, while in very fine, low water a big minnow will sometimes be successful when larger baits fail. Artificial pike baits are legion, but the spoon and phantom still hold their place among the best of them. It is extremely important to have a properly constructed salmon-gut trace, the lead being hung a little below the level of the gut, so that no twisting takes place above it. Immediately below the lead should be a pair of brass swivels, and absolutely none others are required. Such traces are not always kept by tackle dealers, so that the angler frequently has to make them up for himself. The line should be just strong enough to hold the biggest pike likely to be caught, and stouter where many weeds are present than in open water. The rod should be rather stiff, the rings large, and the reel of the Nottingham type with an optional check. With this reel the pike spinner can cast in the Nottingham fashion, or, if he prefers it, in the old-fashioned way which is still practised on the Thames and many other rivers. The bait should be spun slowly, and always as near the haunts of the fish as possible, care being taken to spin it deep enough. In big lakes it is usually trailed behind a boat, just in the way that big trout are fished for. Trolling with the dead gorge bait is prohibited on most waters where pike are preserved, as all fish, little and big, caught by this cruel method are destroyed; but a snap-trolling tackle has been devised which gives very good results. It hooks the fish immediately it seizes it. A leaded spike is forced into the bait from head to tail. At the end of the spike is an eye which projects just beyond the tail, and through this the gimp of the hook is threaded, and two triangles lie alongside the bait. The arrangement is shot quickly down into holes between weeds and worked once or twice with a rather sharp sink-and-draw motion. Pike flies are not much used, except in some of the Irish lakes, but pike take them readily enough on those days when they are feeding close to the surface. The haunts of pike, it may be mentioned, are in running water at the beginning of the season, while as the year advances they get into the deeps, hiding away among rushes, reeds, and weed-beds, ever ready to pounce out on any passing fish. In the winter they lie in quieter waters, particularly in eddies; but it may be taken as a pike-fishing maxim that wherever small fish abound, there will the pike be found.

The minor coarse-fish.

Except for the fact that tackle has been much improved, our knowledge and methods of capturing coarse-fish by what is commonly known as bottom-fishing have not much advanced during the past half-century; but if one fact concerning these fish has become more strongly emphasized than others, it is that to make a handsome creel of barbel (*Barbus vulgaris*), tench (*Tinca vulgaris*), bream (*Abramis brama*), or carp (*Cyprinus carpio*), it is necessary to ground-bait very heavily in advance of the day's sport. The best ground-bait consists of worms, and the best worms come from Nottingham. There seems something peculiar about the soil of that locality which makes the worms specially attractive to the fish. When fishing a baited hole it is good policy to allow the worm and the shot of the float-tackle to lie on the bottom, or a very light leger may be used with or without a float. Worms nowadays are not usually crowded on to a hook, but quite a small hook is used which is merely caught in the tail, head, or middle of the worm. The bait is thus rendered much more attractive than it would otherwise be, and the fish care little for the visible hook. Success very largely depends on keeping quiet, and, so far as possible, out of sight of the fish. Chub (*Leuciscus cephalus*) may be fished for in many ways; but the Nottingham method, by means of which float-tackle is let down to a swim perhaps 20 yards distant, is one of the most deadly, and has become a great favourite with the modern angler. The line used is exceedingly fine, and the operation a very artistic one. The chub, as is well known, also rises to a fly, and may be caught by various baits, such as frogs, slugs, gentles, cockchafers, &c., cast under the boughs by means of a powerful fly-rod. In fishing for roach (*Leuciscus rutilus*) there has been practically no advance in our knowledge of late years. Tackle-makers provide us with finer gut and better hooks, while the roach bite as shyly as ever. For dace (*Leuciscus vulgaris*), however, and sometimes for roach, it has become quite a common practice in some of the larger rivers to rake the bottom behind the punt before commencing to fish. This not only thickens the water slightly, which usually brings fish up into the swim, but also dislodges a quantity of minute fish food which serves as a natural ground-bait. Dace, it has been found, rise well to the dry fly, when rising at all, and may be caught on an absolutely placid surface by this method when the wet fly is useless. (See also SEA-FISHING.)

AUTHORITIES.—H. CHOLMONDELEY-PENNELL and other writers. *Fishing*, 2 vols. (Badminton Library). London: Longmans.—G. M. KELSON. *The Salmon Fly.*—A. E. GATHORNE-HARDY. *The Salmon* (Fur, Feather, and Fin Series). London: Longmans. —The MARQUIS OF GRANBY. *The Trout* (Fur, Feather, and Fin Series). London: Longmans.—F. M. HALFORD. *Dry Fly Fishing in Theory and Practice. Floating Flies and how to dress them.* London: Sampson Low & Co.—JOHN BICKERDYKE. *The Book of the all-round Angler.* London: L. Upcott Gill.—FRANCIS FRANCIS. *A Book on Angling.* London: Longmans.—F. DAY. *The British and Irish Salmonidæ; The Fishes of Great Britain and Ireland.* London: Horace Cox.—T. E. PRITT. *North Country Flies.*—W. SENIOR, JOHN BICKERDYKE, and others. *Pike and Perch* (Fur, Feather, and Fin Series). London: Longmans.—C. H. WHEELEY. *Coarse Fish.* London: Lawrence & Bullen.

("J. B.")

Angola, the general name of the Portuguese possessions on the west coast of Africa lying south of the equator, and embracing Angola proper, which stretches from the mouth of the Congo to the mouth of the Cunene, and the enclave of Cabinda, immediately north of the Congo. Its boundaries are:—On the N., French Congo and the Congo Free State; on the E., the latter and British South Africa; on the S., German South-West Africa; and on the W., the Atlantic. Area, 484,370 square miles; population, estimated at 4,200,000. It embraces part or whole of the basins of the Congo, Kwanza, and Cunene (flowing west), and of the Kubango and Zambezi (flowing east). Of these streams the Congo and Kwanza alone are navigable at their mouths. The coast-line, partly low, partly broken by rocky promontories, possesses the ports of Loanda, Lobito, Benguela, Mossamedes, Porto Alexandre, and Bahia dos Tigres. There are various mountain chains and tablelands running generally parallel to the coast, as Tala Mugongo (4400 feet), Chella and Vissécua (5250 to 6500 feet). In the region of Bailundo are the highest points of the province, viz., Lovili (7780 feet), in 12° 5′ S. lat., and Mt. Elonga (7550 feet). South of the Kwanza is the volcanic Mt. Caculo-Cabaza (3300 feet).

With the exception of the district of Mossamedes, the coast districts (the palm country) are unsuited to Europeans. On the interior plateau, above 3300 feet, the temperature and rainfall, together with malaria, decrease southwards as far as the lower course of the Cunene. The mean annual temperature at São Salvador do Congo is 72°·5 Fahr.; at Loanda, 74°·3; and at Caconda, 67°·2. The climate is greatly influenced by the prevailing winds, which are west, south-west, and S.S.W. Two seasons are distinguished—the cool, from June to September; and the rainy, from October to May. The heaviest rainfall occurs in April, and is accompanied by violent storms. The minerals comprise copper at Bembe, on the M'Brija and the Cuvo; iron, at Oeiras (on the Lucalla) and in Bailundo; petroleum in Dande and Quinzáo; gold in Lombija and Cassinga; and mineral salt at Quissama. Behind a region of intermingled grassy plains and palms (especially the Guinea palm, *Elæis guineensis*) follows a region of savannahs proper and low hills with scanty vegetation. In the south this latter region merges into a barren sandy desert, with *Welwitschia mirabilis* and *Bauhinia*. Amongst the cultivated products are the sugar-cane, cotton tree, coffee, and tobacco; and the exports include coffee, india-rubber, wax, vegetable oils, cocoa-nuts, brandy, cotton, and ivory. In 1896 the coffee crop weighed 4907 tons, and was valued at £329,550, as compared with 1142 tons in 1870; and in the same year the india-rubber crop weighed 2245 tons, valued at £525,550. The yield of wax was valued at £68,450. Industry is not greatly developed; but distilling, and the manufacture of tobacco, bricks, and tiles, and cottons, and the salting of fish are carried on. In 1896 the exports reached a total value of £1,025,100; and to this must be added £222,250, as the annual average exportation of the Congo district, or in all £1,247,350. In the same year the imports totalled £766,700, the principal item being textiles (£368,900, of which £174,900, or nearly one-half, came from Lisbon). In 1899 the exports reached £1,768,554, and the imports totalled £1,536,049. The total commerce of the province has nearly quadrupled since 1870, i.e., it has increased from £827,800 (1870) to £3,304,603 (1899). In 1897 the ports of the province were entered and cleared by an aggregate of 3384 vessels of 1,123,289 tons. There is a railway from Loanda to Ambaca; including this line, and others building, the province possesses 200 miles of railway. There are 670 miles of telegraphs. The native population consists of Bushmen, Jagas or Iaccas (Bangala), and Bantus. The province is divided into five districts—Congo, Loanda, Benguela, Mossamedes, and Lunda. The province, the capital of which is Loanda (or Luanda), is administered by a governor-general. It forms a bishopric of the ecclesiastical province of Lisbon.

See E. DE VASCONCELLOS. *As Colonias Portuguezas.* Lisbon, 1896-97. (E. DE V.)

Angora, (1) a Turkish viláyet in north-central Asia Minor, which includes most of the ancient Galatia. It is an agricultural country, depending for its prosperity on its grain and the mohair obtained from the Ángora goats—average annual clip 3,300,000 lb. The only important industry is carpet-weaving at Kir-shehr and Kaisarieh. There are mines of silver, copper, lignite, and salt, and many hot springs, including some of great repute medicinally. Average annual exports, 1896-98, £920,762; imports, £411,836. Population, 900,000 (Moslems, 765,000; Christians, 135,000). (2) The chief town of the viláyet, classical *Ancyra*, Turkish *Enguri*, situated on the left bank of the Enguri Su, a tributary of the Sakaria, on the slopes of a rocky hill which rises 500 feet above the plain, and is crowned by the ruins of the old citadel.

Christianity was probably introduced at an early date, but there is no evidence that the Ancyran church was founded by St Paul, or that he ever visited North Galatia. The town was captured by the Persians, the Arabs, the Seljúk Turks, and the Crusaders before it passed to the Osmanli Turks. In 1832 it was taken by the Egyptians. Ángora is connected with Constantinople by railway, and exports mohair, grain, and yellow berries. Mohair cloth is manufactured, and the town is noted for its honey and fruit. From 1639 to 1768 there was an agency of the Levant Company at Ángora, and there is now a British consul. Population, 30,000 (Moslems, 18,000; Christians, chiefly Roman Catholic Armenians, 11,500; Jews, 500). (C. W. W.)

Angostura. See CIUDAD BOLIVAR.

Angoulême, chief town of the department of Charente, France, 277 miles S.S.W. of Paris, on the railway from Paris to Bordeaux. Seven suburbs surround the town—Honmeau, Saint Ausonne, St Martin, St Cybard, la Bussatte, les Béziers, and St Roch. In addition to other industries it has manufactures of boots and shoes and gloves, wire drawing and rolling mills, and copper founding. Great commerce is carried on in wine, brandy, and paper, and the "pierres d'Angoulême" quarried in the neighbourhood. Population (1881), 25,750; (1891), 28,515; (1896), 30,616; (1901), 37,650.

Anguilla, or SNAKE, a small island now included in the Presidency of St Kitts-Nevis in the British colony of the Leeward Islands. The destruction of trees by charcoal-burners has resulted in the almost complete deforestation of the island. Nearly all the land is in the hands of peasant proprietors, who cultivate sweet potatoes, peas, beans, corn, &c., and rear sheep and goats. Salt is still exported. The population in 1891 amounted to 3699 (123 white, 757 coloured, 2819 negroes).

Anhalt, a duchy of Germany, situated on the Elbe and Saale, and almost surrounded by the Prussian province of Saxony. Agriculture supports some 71,170 of the population, *i.e.*, 24 per cent. of the whole. The principal crops grown are beetroot (for sugar) and potatoes; then come hay, rye, barley, wheat, oats, and tobacco. In 1897 there were in the duchy 18,515 horses, 67,100 cattle, 90,815 pigs, and 91,815 sheep. In 1895, out of a total of 32,280 farms, no less than 22,192, or 68·7 per cent., were less than 2½ acres in area, 7530 between 2½ and 25 acres, 2393 between 25 and 250 acres, and only 165 more than 250 acres. In 1898-99 the sugar refineries produced 83,718 tons of sugar, the breweries 10,472,000 gallons of beer, and the distilleries (1897) 763,000 gallons of pure alcohol. In 1897 the mines produced 1,219,704 tons of lignite, valued at £169,500; 208,664 tons of coal, valued at £42,350; and 44,712 tons of chloride of potassium, valued at £339,100. The population was 232,592 in 1880, 271,963 in 1890, and 316,085 in 1900, of whom 155,185 were males and 160,900 females. All the population, except (1895) 8639 Roman Catholics and 1611 Jews, were members of the Reformed church. In the period 1891-98 inclusive, 101 persons on an average emigrated every year. In the year 1900-1901 the revenue and expenditure balanced at £1,384,823. The public debt amounted in 1899 to £9375, and the state contribution to the empire in 1900 to £127,710.

Ani, an Armenian city of importance in the Middle Ages, now in Russian territory, situated between the Arpa Chai, *Harpasus*, and a deep ravine. In the 9th century it became the capital of the Bagratid kings of Armenia, and when yielded to the Byzantine emperor, 1046, it was a populous city. Soon afterwards it was taken by the Seljúk Turks, and its ruin was completed by the Mongols in the 13th century. Its remains are of great interest, especially those of its churches, which throw much light on the Church architecture of Armenia.

Aniches, an industrial town of France, department of Nord, in the arrondissement of Douai, 12 miles S. by E. of Lille, on railway from Cambrai to Valenciennes. It has rich coal mines and is the seat of one of the most important glass-works in France. Population (1881), 4967; (1891) 6296; (1896) 6437, (comm.) 6924.

Animal Heat. See PHYSIOLOGY.

Anjer, formerly a seaport town on the strait of Sunda, Java, 60 miles W. of Batavia. It was destroyed by the inundation caused by the eruption of Krakatao in August 1883. The telegraph cable between Java and Sumatra terminates at Anjer Kidoel, or New Anjer, 3 miles south of the old site.

Anklam, a town of Prussia, province Pomerania, near the mouth of the river Peene, 53 miles N.W. from Stettin by the railway to Stralsund. The church of St. Mary (12th century) has a new tower 335 ft. high. There is here a military school. The industries consist of iron-foundries and factories for sugar and soap. Population (1885), 12,786; (1895), 13,560; (1900), 14,602.

Ankober. See ABYSSINIA.

Annaberg, a town of Germany, Saxony, 6 miles from the frontier of Bohemia, 18½ miles S. by E. of Chemnitz by rail. It has an industrial female school, besides schools for lace, agriculture, commerce, and music. The mining industry has greatly declined. Population (1890), 14,960; (1900), 15,957.

Annam. See TONGKING, COCHIN-CHINA, and INDO-CHINA.

Annan, a royal and parliamentary burgh (Dumfries group), and port of Dumfriesshire, Scotland, standing on the east bank of the river Annan, 93¼ miles S.S.E. of Glasgow by rail. A harbour trust was constituted in 1897, and the harbour accommodation has been improved. The town hall has been rebuilt. Among the industries are sandstone quarrying, cotton manufacture, distilling, boat-building, and nursery gardening. Large marine engineering works have been established in the vicinity. Population of town in 1891, 4860; in 1901, 5804.

Annapolis, a city and seaport of Maryland, U.S.A., the capital of the state and of Anne Arundel county. It is connected by rail with Washington and Baltimore. The U.S. Naval Academy buildings were being rebuilt in 1901, the improvements consisting of cadets' quarters, armoury, boat-house, and a new sea-wall, the whole estimated to cost $8,000,000, the sum authorized by Congress. In 1900 there were 280 cadets at the Academy. Population (1880), 6642; (1890), 7604; (1900), 8402.

Ann Arbor, a city of Michigan, U.S.A., the capital of Washtenaw county. It is situated in the south-eastern part of the lower peninsula, at an altitude of 771 feet. It is divided into six wards, and is entered by two railways, the Ann Arbor and the Michigan Central. It is a university town, with little in the way of manufactures or commerce. Population (1880), 8061; (1890), 9431; (1900), 14,509.

Annecy, chief town of the department of Haute Savoie, France, 401 miles S.E. of Paris, on railway from Aix-les-Bains to Geneva, situated at the north end of Lake Annecy, partly on small islands formed by three canals known as the *Thioux*. Its library, noteworthy as being the oldest in Savoie, contains 12,000 volumes, and there is a fine public garden with a statue of Berthollet, a native of this place. Its manufactures, less important than formerly, include paper and felt hats. Population (1881), 9144; (1896), 9436 (comm.), 10,009; (1901), 13,611.

Annelida is a term now seldom used in modern zoology. In 1875, when the article under that name appeared in the ninth edition of this work, it represented a class of organisms of which even at that date our knowledge had so far advanced as to make it impracticable to give a satisfactorily sharp-cut definition of the term. It then included the following orders:—

i. POLYCHÆTA (marine worms).
ii. OLIGOCHÆTA (land and fresh-water worms).
iii. ONYCHOPHORA (Peripatus).
iv. DISCOPHORA (leeches).
v. GEPHYREA.

These have now been redistributed, and the following table represents a widely accepted view of their classification, and also shows the headings under which reference will be found in the *Ency. Brit.* (ninth edition or Supplement):—

Classes and Orders.	Articles.
i. CHÆTOPODA— a. Polychæta. b. Archiannelida. c. Myzostomida. d. Oligochæta.	WORM.
ii. ECHIUROIDEA = GEPHYREA ARMATA.	ECHIUROIDEA.
iii. HIRUDINEA = DISCOPHORA.	LEECH.
iv. SIPUNCULOIDEA v. PRIAPULOIDEA } GEPHYREA INERMIA.	SIPUNCULOIDEA.
vi. ONYCHOPHORA = PROTRACHEATA.	PERIPATUS.

The first three of these six classes have been shown on anatomical and embryological grounds to have considerable affinity to one another, and are generally admitted to have been derived from a common ancestor of marine habit and chætopodan type—chætopodan in its segmentation, in the possession of a true excretory cœlom and of setæ (chætæ) formed in ectodermal sacs, and in certain definite characters of the nervous and circulatory systems. The second two groups, which are now placed apart from the Echiuroidea, with which they were formerly united as Gephyrea, may prove to be less closely allied to one another; the affinities of Sipunculoidea are perhaps to be sought with Phoronis and the Hemichorda. As to the position of Peripatus in the animal kingdom, in spite of most complete studies of the anatomy and embryology of numerous species, no general agreement can be said to have been reached by zoologists; its affinities seem to point on the one hand to a chætopodan origin, on the other to relationship with Tracheata (see ARTHROPODA, PERIPATUS).

Anniston, a city of Calhoun county, Alabama, U.S.A., situated in 33° 39′ N. lat. and 85° 50′ W. long., at an altitude of 693 feet. For a time it grew rapidly as a centre of iron manufacture, in which it is favoured by having ore, coal, and limestone in close proximity. It has several blast furnaces and rolling mills, besides numerous other establishments for the manufacture of iron and steel. It has two railways, the Southern and the Louisville and Nashville. Population (1880), 942; (1890), 9998; (1900), 9695.

Annuities, Terminable (BRITISH GOVERNMENT).—Terminable Annuities were introduced into, and have been employed in, the system of British public finance as a means of reducing the National Debt. This result is attained by substituting for a perpetual annual charge (or one lasting until the capital which it represents can be paid off *en bloc*), an annual charge of a larger amount, but lasting for a shorter term. The latter is so calculated as to pay off, during its existence, the capital which it replaces, with interest at an assumed or agreed rate, and under specified conditions. The theoretical bases of such calculations are explained in the article "ANNUITIES" in the ninth edition of this work. The practical effect of the substitution of a terminable annuity for an obligation of longer currency is to bind the present generation of citizens to increase its own obligations in the present and near future in order to diminish those of its successors. This end might be attained in other ways; for instance, by setting aside out of revenue a fixed annual sum for the purchase and cancellation of debt (Pitt's method, in intention), or by fixing the annual debt charge at a figure sufficient to provide a margin for reduction of the principal of the debt beyond the amount required for interest (Sir Stafford Northcote's method), or by providing an annual surplus of revenue over expenditure (the "old Sinking Fund"), available for the same purpose. All these methods have been tried in the course of British financial history, and the second and third of them are still employed; but on the whole the method of terminable annuities has been the one preferred by Chancellors of the Exchequer and by Parliament.

Terminable annuities, as employed by the British Government, fall under two heads:—(*a*) Those issued to, or held by private persons; (*b*) those held by Government departments, or by funds under Government control. The important difference between these two classes is that an annuity under (*a*), once created, cannot be modified except with the holder's consent, *i.e.* is practically unalterable without a breach of public faith; whereas an annuity under (*b*) can, if necessary, be altered by inter-departmental arrangement under the authority of Parliament. Thus annuities of class (*a*) fulfil most perfectly the object of the system as explained above; while those of class (*b*) have the advantage that in times of emergency their operation can be suspended without any inconvenience or breach of faith, with the result that the resources of Government can on such occasions be materially increased, apart from any additional taxation. For this purpose it is only necessary to retain as a charge on the income of the year a sum equal to the (smaller) perpetual charge which was originally replaced by the (larger) terminable charge, whereupon the difference between the two amounts is temporarily released, while ultimately the increased charge is extended for a period equal to that for which it is suspended. The terminable annuities of class (*b*) were dealt with in this manner in 1885-86 and in 1900-1901.

Annuities of class (*a*) were first instituted in 1808, but are at present mainly regulated by an Act of 1829. They may be granted either for a specified life, or two lives, or for an arbitrary term of years; and the consideration for them may take the form either of cash or of Government stock, the latter being cancelled when the annuity is set up. The total amount of permanent debt cancelled by these means from 1808 to 31st March 1890 was about 77½ millions: the charge on the Exchequer for such annuities in the year 1898-99 was £1,284,000; the amount of stock and cash applied in the same year to the purchase of fresh annuities was £1,119,000; and the annuities issued are valued at about ten years' purchase. These figures consist almost wholly of annuities for lives. It may be inferred from the published returns that the net reduction of debt since 1890 by this channel has amounted on the average to nearly £900,000 a year, so that the total reduction of debt by this means, up to 1900, must have been about 86 millions.

Annuities (*b*) held by Government departments date from 1863. They have been created in exchange for permanent debt surrendered for cancellation, the principal operations having been effected in 1863, 1867, 1870, 1874, 1883, and 1899. The amount so cancelled up to 1883 inclusive was £118,242,000, and as the capital value of the terminable annuities of this class outstanding on 31st March 1899 was £22,765,000, it may be concluded that nearly 100 millions of permanent debt will have been extinguished by this method at the end of the century. The amount of permanent debt cancelled and converted into terminable annuities in 1899 was twenty-eight millions.

Annuities of this class (*b*) do not affect the public at all, except of course in their effect on the market for Government securities. They are merely financial operations between the Government, in its capacity as the banker of savings banks and other funds, and itself, in the capacity of custodian of the national finances. Savings bank depositors are not concerned with the manner in which Government invests their money, their rights being confined to the receipt of interest and the repayment of deposits upon specified conditions. The case is, however, different as regards forty millions of consols (included in the above figures), belonging to suitors in Chancery, which were cancelled and replaced by a terminable annuity in 1883. As the liability to the suitors in that case was for a specified amount of stock, special arrangements were made to ensure the ultimate replacement of the precise amount of stock cancelled.

Altogether, therefore, it appears that during the 19th century over two hundred millions of the permanent national debt of the United Kingdom were cancelled or put in course of cancellation by means of terminable annuities.

See *Report of the Proceedings of the Commissioners for the Reduction of the National Debt*, 1891, Parliamentary Paper, C. 6539.

(S. E. S.-R.)

Ansbach, a town of Bavaria, Germany, district Middle Franconia, 27 miles by rail S.W. from Nuremberg. There are a new municipal museum and a special technical school. Ansbach possesses monuments to the native poets Platen and Uz, and to Caspar Hauser, the "wild boy," who died here in 1833. Population (1885), 13,935; (1895), 15,883; (1900), 17,555.

Ansonia, a town and city of New Haven county, Connecticut, U.S.A. It is situated on the Naugatuck, just above its junction with the Housatonic, in the southern part of the state, 12 miles north-west of New Haven. It is divided into five wards, and its plan is quite irregular. The New York, New Haven, and Hartford Railway furnishes communication. Its manufactures, depending on the river for water-power, are chiefly in brass and iron. Its clocks have long been well known. Population (1890), 10,342; (1900), 12,681.

Anstruther, Easter and **Wester,** a fishing town and railway station of Fifeshire, Scotland, in the St Andrews group of parliamentary burghs, 9 miles S.S.E. of St Andrews. The harbour was completed in 1877 at a cost of over £80,000. An endowed higher-class school was opened in 1886. Population, 2000.

Antalo. See ABYSSINIA.

Antanànarivo, the capital of Madagascar, situated centrally as regards the length of the island, but only about 90 miles distant from the eastern coast, in 18° 55′ S. lat. and 47° 31′ E. long. The city occupies a commanding position, being chiefly built on the summit and slopes of a long and narrow rocky ridge, which extends north and south for about two and a half miles, and rises at its highest point to nearly 700 feet above the extensive rice-plain to the west, which is itself 4000 feet above sea-level. For long only the principal village of the Hova chiefs, Antanànarivo advanced in importance as those chiefs made themselves sovereigns of Madagascar until it became a town of some 80,000 inhabitants. Until 1869 all buildings within the city proper were of wood or rush, but even then it possessed several timber palaces of considerable size, the largest being 120 feet high. Since the introduction of stone and brick for building, the whole city has been rebuilt, and it now contains numerous structures of some architectural pretensions, the royal palaces, the houses of the prime minister and nobles, the French residency, the Anglican and Roman Catholic cathedrals, several stone churches (as well as others of brick), colleges, schools, hospitals, courts of justice and other Government buildings, and hundreds of good dwelling-houses. Since the French conquest in 1895 good roads have been constructed throughout the city, and the central space, called "Andohàlo," has become a handsome *place*, with walks and terraces, flower-beds, and trees. Water is obtained from several springs at the foot of the hill, but the supply is scanty. The population is now about 60,000, but varies somewhat at different periods. The city is guarded by two forts built on hills to the east and south-west respectively (J. SI.*)

Antarctic. See POLAR REGIONS.

Antelope.—Our knowledge of the group of ruminants, commonly known as antelopes, has greatly increased of late years, and a new treatment of the subject is now necessary. There is some uncertainty as to the origin of the name, but it is not improbably derived from *Pantholops*, the old Coptic term for the unicorn. It properly denotes the Indian black buck, which alone constitutes the genus *Antilope*, with the title of *A. cervicapra*, but the term has been extended to embrace a very large group of hollow-horned ruminants, or *Bovidæ*, which do not come under the designation of oxen, sheep, or goats —the prong-buck of America (*Antilocapra americana*) being, however, excluded, and forming a family by itself. The group, which scarcely admits of exact definition, is divided into several subfamilies, the majority of which are restricted to Africa (or Africa and Arabia), where more than one hundred different species are known to exist.

The first subfamily (*Bubalinæ*) includes the hartebeests (*Bubalis* and *Damaliscus*) and the gnus or wildebeests (*Connochætes*), all of which are large antelopes confined to Africa, with the exception of one Arabian species. The typical hartebeests (*Bubalis*) are short-haired animals, with high withers, long faces, and sharply bent ridged horns, but in the blesbok and its allies (*Damaliscus*) the last three features are less marked. Heavy heads, smooth horns, long manes, and horse-like tails sufficiently characterize the gnus. The second subfamily, or *Cephalophinæ*, includes small or medium-sized species, represented only by the duikers or "divers" (*Cephalophus*) of Africa, and the four-horned antelope (*Tetraceros*) of India. All have naked muzzles, elongated face-glands or tear-pits, false hoofs, and four mammæ, but there are no hair-tufts at the knees. The short and upright horns are generally present in both sexes. A third group, *Oreotraginæ*, exclusively African, is represented by a number of small forms, such as the tiny dik-diks (*Madoqua*), oribis (*Oribia*), sunis (*Nesotragus*), steinboks (*Rhaphiceros*), and the active klipspringer (*Oreotragus*). Of much larger size are the African water-bucks and kobs (*Cobus*) and reed-bucks (*Cervicapra*), which constitute the subfamily *Cervicaprinæ*, and include some of the handsomest of all antelopes, among them being the black *Cobus maria* and *C. leucotis* of the swamps of the White Nile. The muzzle is naked and the females are hornless. The Vaal rhebok (*Pelea*) likewise belongs to this group. In the typical subfamily or *Antilopinæ*, in which the females are also generally without horns, are included the Indian black buck (*Antilope*), the graceful African pala (*Æpyceros*), the puffy-nosed saiga (*Saiga*) of Central Asia, the long-horned chiru (*Pantholops*) of Tibet, the South African spring-buck (*Antidorcas*), the numerous and widely-spread group of gazelles (*Gazella*), and the dibatag (*Ammodorcas*), the long-necked gerenuk (*Lithocranius*), and the tiny beira (*Dorcatragus*) of Somaliland and East Africa. Widely different from all the foregoing is the African group of *Hippotraginæ*, all the members of which are of large size and have long horns in both sexes. Among these are the sable and the roan antelope (*Hippotragus*), with sabre-like horns, the straight-horned gemsbok and beisa (*Oryx*), and the long-haired and spiral-horned addax of the Sahara. The last group of what may be termed true antelopes is the *Tragelaphinæ*, in which the size is mostly large, and the spirally twisted horns are, excepting in the elands, restricted to the males. The sole non-African representative of the group is the Indian nilgai (*Boselaphus*), in which the horns are much shorter than in the rest. The African forms include the beautiful bush-bucks or harnessed antelopes (*Tragelaphus*), in which the females are often more brightly coloured than the males, the striped kudus (*Strepsiceros*), and the elands (*Taurotragus*), which are the largest of all antelopes. The remaining group (*Rupicaprinæ*), which indicates a transition towards the goats, is represented by the chamois (*Rupicapra*) of the mountains of Southern Europe, the gorals (*Urotragus*) and serows (*Nemorhædus*) of Eastern Asia, the takin (*Budorcas*) of the Mishmi Hills and Tibet, and the so-called Rocky Mountain goat (*Oreamnus*) of North America, which is the sole transatlantic representative of the antelopes, if indeed it be entitled to be called an antelope at all. (R. L.*)

Antequera, a city of Spain, province of Malaga, 28 miles N. of Malaga. Since 1890 a thriving industry has been created by beetroot and cane-sugar factories, employing several thousand hands. Population, 24,387.

ANTHOZOA.

ALTHOUGH corals have been familiar objects since the days of antiquity, and the variety known as the precious red coral has been for a long time an article of commerce in the Mediterranean, it was only in the 18th century that their true nature and structure came to be understood. By the ancients and the earlier naturalists of the Christian era they were regarded either as petrifactions or as plants, and many supposed that they occupied a position midway between minerals and plants. The discovery of the animal nature of red coral is due to J. A. de Peyssonel, a native of Marseilles, who obtained living specimens from the coral fishers on the coast of Barbary and kept them alive in aquaria. He was thus able to see that the so-called "flowers of coral" were in fact nothing else than minute polyps resembling sea-anemones. His discovery, made in 1727, was rejected by the Academy of Sciences of France, but eventually found acceptance at the hands of the Royal Society of London, and was published by that body in 1751. The structure and classification of polyps, however, were at that time very imperfectly understood, and it was fully a century before the true anatomical characters and systematic position of corals were placed on a secure basis.

The hard calcareous substance to which the name coral is applied is the supporting skeleton of certain members of the *Anthozoa*, one of the classes of the phylum Cœlentera. The most familiar Anthozoan is the common sea-anemone, *Actinia equina*, L., and it will serve, although it does not form a skeleton or *corallum*, as a good example of the structure of a typical Anthozoan polyp or zooid. The individual animal or zooid of *Actinia equina* has the form of a column fixed by one extremity, called the *base*, to a rock or other object, and bearing at the opposite extremity a crown of *tentacles*. The tentacles surround an area known as the *peristome*, in the middle of which there is an elongated mouth-opening surrounded by tumid lips. The mouth does not open directly into the general cavity of the body, as is the case in a hydrozoan polyp, but into a short tube called the *stomodæum*, which in its turn opens below into the general body-cavity or *cœlenteron*. In Actinia and its allies, and most generally, though not invariably, in Anthozoa, the stomodæum is not circular, but is compressed from side to side so as to be oval or slit-like in transverse section. At each end of the oval there is a groove lined by specially long vibratile cilia. These grooves are known as the *sulcus* and *sulculus*, and will be more particularly described hereafter. The elongation of the mouth and stomodæum confer a bilateral symmetry on the body of the zooid, which is extended to other organs of the body. In Actinia, as in all Anthozoan zooids, the cœlenteron is not a simple cavity, as in a Hydroid, but is divided by a number of radial folds or curtains of soft tissue into a corresponding number of radial chambers. These radial folds are known as *mesenteries*, and their position and relations may be understood by reference to Figs. 1 and 2. Each mesentery is attached by its upper margin to the peristome, by its outer margin to the body-wall, and by its lower margin to the basal disc. A certain number of mesenteries, known as complete mesenteries, are attached by the upper parts of their internal margins to the stomodæum, but below this level their edges hang free in the cœlenteron. Other mesenteries, called incomplete, are not attached to the stomodæum, and their internal margins are free from the peristome to the basal disc. The lower part of the free edge of every mesentery, whether complete or incomplete, is thrown into numerous puckers or folds, and is furnished with a glandular thickening known as a *mesenterial filament*. The reproductive organs or gonads are borne on the mesenteries, the germinal cells being derived from the inner layer or endoderm.

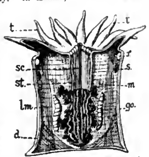


Fig. 1.—Diagrammatic longitudinal section of an Anthozoan zooid. *m*, mesentery; *t*, tentacles; *st*, stomodæum; *sc*, sulcus; *r*, Rotteken's muscle; *s*, stoma; *lm*, longitudinal muscle; *d*, diagonal muscle; *go*, gonads.

In common with all Cœlenterate animals, the walls of the columnar body and also the tentacles and peristome of Actinia are composed of three layers of tissue. The external layer, or *ectoderm*, is made up of cells, and contains also muscular and nervous elements. The preponderating elements of the ectodermic layer are elongated columnar cells, each containing a nucleus, and bearing cilia at their free extremities. Packed in among these are *gland cells*, *sense cells*, and *cnidoblasts*. The last-named are specially numerous on the tentacles and on some other regions of the body, and produce the well-known "thread cells," or *nemato-cysts*, so characteristic of the Cœlentera. The inner layer or endoderm is also a cellular layer, and is chiefly made up of columnar cells, each bearing a cilium at its free extremity and terminating internally in a long muscular fibre. Such cells, made up of epithelial and muscular components, are known as epithelio-muscular cells. In Actinians the epithelio-muscular cells of the endoderm are crowded with yellow spherical bodies, which are unicellular plants or Algæ, living symbiotically in the tissues of the zooid. The endoderm contains in addition gland cells and nervous elements. The middle layer or mesoglœa is not originally a cellular layer, but a gelatinoid structureless substance, secreted by the two cellular layers. In the course of development, however, cells from the ectoderm and endoderm may migrate into it. In *Actinia equina* the mesoglœa consists of fine fibres imbedded in a homogeneous matrix, and between the fibres are minute branched or spindle-shaped cells. For further details of the structure of Actinians, the reader should consult the work of O. and R. Hertwig (9).

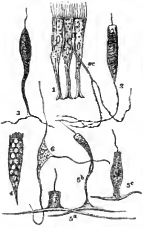


FIG. 2.—1, Portion of epithelium from the tentacle of an Actinian, showing three supporting cells and one sense cell (*sc*). 2, A cnidoblast with enclosed nematocyst from the same specimen. 3 and 4, Two forms of gland cell from the stomodæum. 5*a*, 5*b*, Epithelio-muscular cells from the tentacle in different states of contraction. 5*c*, An epithelio-muscular cell from the endoderm, containing a symbiotic zooxanthella. 6, A ganglion cell from the ectoderm of the peristome. (After O. and R. Hertwig.)

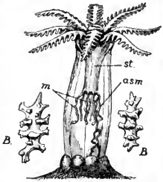


FIG. 3.—An expanded Alcyonarian zooid, showing the mouth surrounded by eight pinnate tentacles. *st*, stomodæum in the centre of the transparent body; *m*, mesenteries; *asm*, asulcar mesenteries; B, spicules, enlarged.

The Anthozoa are divisible into two sub-classes, sharply marked off from one another by definite anatomical characters. These are the ALCYONARIA and the ZOANTHARIA. To the first-named belong the precious red coral and its allies, the sea-fans or Gorgoniæ; to the second belong the white or Madreporarian corals.

Alcyonaria.—In this sub-class the zooid (Fig. 3) has very constant anatomical characters, differing in some important respects from the Actinian zooid, which has been taken as a type. There is only one ciliated groove, the sulcus, in the stomodæum. There are always eight tentacles, which are hollow and fringed on their sides, with hollow projections or pinnæ; and always eight mesenteries, all of which are complete, *i.e.*, inserted on the stomodæum. The mesenteries are provided with well-developed longitudinal retractor muscles, supported on longitudinal folds or plaits of the mesoglœa, so that in cross-section they have a branched appearance. These *muscle-banners*, as they are called, have a highly characteristic arrangement; they are all situated on those faces of the mesenteries which look towards the sulcus (Fig. 4). Each mesentery has a filament; but two of them, namely, the pair farthest from the sulcus, are longer than the rest, and have a different form of filament. It has been shown that these asulcar filaments are derived from the ectoderm, the remainder from the endoderm. The only exceptions to this structure are found in the arrested or modified zooids, which occur in many of the colonial Alcyonaria. In these the tentacles are stunted or suppressed and the mesenteries are ill-developed, but the sulcus is unusually large and has long cilia. Such modified zooids are called siphonozooids, their function being to drive currents of fluid through the canal-systems of the colonies to which they belong. With very few exceptions a calcareous skeleton is present in all Alcyonaria; it usually consists of spicules of carbonate of lime, each spicule being formed within an ectodermic cell (Fig. 3, B). Most commonly the spicule-forming cells pass out of the ectoderm and are imbedded in the mesoglœa, where they may remain separate from one another or may be fused together to form a strong mass. In addition to the spicular skeleton an organic horny skeleton is frequently present, either in the form of a horny external investment (Cornularia), or an internal axis (Gorgonia) or it may form a matrix in which spicules are imbedded (Keroeides, Melitodes).

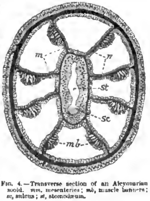


FIG. 4.—Transverse section of an Alcyonarian zooid. *m*, mesenteries; *mb*, muscle banners; *sc*, sulcus; *st*, stomodæum.

Nearly all the Alcyonaria are colonial. Four solitary species have been described, viz., *Haimea funebris* and *H. hyalina*, *Hartea elegans*, and *Monoxenia Darwinii*; but it is doubtful whether these are not the young forms of colonies. For the present the solitary forms may be placed in a grade, *Protalcyonacea*; and the colonial forms may be grouped in another grade, *Synalcyonacea*. Every Alcyonarian colony is developed by budding from a single parent zooid. The buds are not direct outgrowths of the body-wall, but are formed on the courses of hollow outgrowths of the base or body-wall, called *solenia*. These form a more or less complicated canal system, lined by endoderm, and communicating with the cavities of the zooids. The most simple form of budding is found in the genus *Cornularia*, in which the mother zooid gives off from its base one or more simple radiciform outgrowths. Each outgrowth contains a single tube or solenium, and at a longer or shorter distance from the mother zooid a daughter zooid is formed as a bud. This gives off new outgrowths, and these, branching and anastomosing with one another, may form a network, adhering to stones, corals, or other objects, from which zooids arise at intervals. In *Clavularia* and its allies each outgrowth contains several solenia, and the outgrowths may take the form of flat expansions, composed of a number of solenial tubes felted together to form a lamellar surface of attachment. Such outgrowths are called *stolons*, and a stolon may be simple, *i.e.*, contain only one solenium, as in *Cornularia*, or may be complex and built up of many solenia, as in *Clavularia*. Further complications arise when the lower walls of the mother zooid become thickened and interpenetrated with solenia, from which buds are developed, so that lobose, tufted, or branched colonies are formed. The chief orders of the Synalcyonacea are founded upon the different architectural features of colonies produced by different modes of budding. We recognize six orders—the STOLONIFERA, ALCYONACEA, PSEUDAXONIA, AXIFERA, STELECHOTOKEA, and CŒNOTHECALIA.

In the order STOLONIFERA the zooids spring at intervals from branching or lamellar stolons, and are usually free from one another, except at their bases, but in some cases horizontal solenia arising at various heights from the body-wall may place the more distal portions of the zooids in communication with one another. In the genus *Tubipora* these horizontal solenia unite to form a series of horizontal platforms (Fig. 5). The order comprises the families *Cornulariidæ*, *Syringoporidæ*, *Tubiporidæ*, and *Favositidæ*. In the first-named the zooids are united only by their bases and the skeleton consists of loose spicules. In the *Tubiporidæ* the spicules of the proximal part of the body-wall are fused together to form a firm tube, the corallite, into which the distal part of the zooid can be retracted. The corallites are connected at intervals by horizontal platforms containing solenia, and at the level of each platform the cavity of the corallite is divided by a transverse calcareous partition, either flat or cup-shaped, called a *tabula*. Formerly all corals in which tabulæ are present were classed together as Tabulata, but Tubipora is an undoubted Alcyonarian with a lamellar stolon, and the structure of the fossil genus Syringopora, which has vertical corallites united by horizontal solenia, clearly shows its affinity to Tubipora. The Favositidæ, a fossil family from the Silurian and Devonian, have a massive corallum composed of numerous polygonal corallites closely packed together. The cavities of adjacent corallites communicate by means of numerous perforations, which appear to represent solenia, and numerous transverse tabulæ are also present. In *Favosites hemisphærica* a number of radial spines, projecting into the cavity of the corallite, give it the appearance of a madreporarian coral.

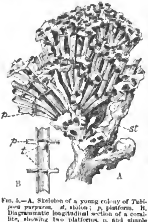


FIG. 5.—A, Skeleton of a young colony of *Tubipora purpurea*. *st*, stolon; *p*, platform. B, Diagrammatic longitudinal section of a corallite, showing two platforms, *p*, and simple and cup-shaped tabulæ, *t*. (After Hickson.)

In the order ALCYONACEA the colony consists of bunches of elongate cylindrical zooids, whose proximal portions are united by solenia and compacted, by fusion of their own walls and those of the solenia, into a fleshy mass called the cœnenchyma. Thus the cœnenchyma forms a stem, sometimes branched, from the surface of which the free portions of the zooids project. The skeleton of the Alcyonacea consists of separate calcareous spicules, which are often, especially in the Nephthyidæ, so abundant and so closely interlocked as to form a tolerably firm and hard armour. The order comprises the families *Xeniidæ*, *Alcyonidæ*, and *Nephthyidæ*. *Alcyonium digitatum*, a pink digitate form popularly known as "dead men's fingers," is common in 10-20 fathoms of water off the English coasts.

In the order PSEUDAXONIA the colonies are upright and branched, consisting of a number of short zooids whose proximal ends are imbedded in a cœnenchyma containing numerous ramifying solenia and spicules. The cœnenchyma is further differentiated into a medullary portion and a cortex. The latter contains the proximal moieties of the zooids and numerous but separate spicules. The medullary portion is densely crowded with spicules of different shape from those in the cortex, and in some forms the spicules are cemented together to form a hard supporting axis. There are four families of Pseudaxonia—the *Briareidæ*, *Sclerogorgidæ*, *Melitodidæ*, and *Corallidæ*. In the first-named the medulla is penetrated by solenia and forms an indistinct axis; in the remainder the medulla is devoid of solenia, and in the *Melitodidæ* and *Corallidæ* it forms a dense axis, which in the *Melitodidæ* consists of alternate calcareous and horny joints. The precious red coral of commerce, *Corallium rubrum* (Fig. 6), a member of the family *Corallidæ*, is found at depths varying from 15 to 120 fathoms in the Mediterranean Sea, chiefly on the African coast. It owes its commercial value to the beauty of its hard red calcareous axis, which in life is covered by a cortex in which the proximal moieties of the zooids are imbedded. *Corallium rubrum* has been the subject of a beautifully-illustrated memoir by de Lacaze Duthiers, which should be consulted for details of anatomy.

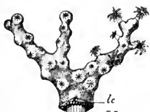


FIG. 6.—Portion of a colony of *Corallium rubrum*, showing expanded and contracted zooids. In the lower part of the figure the cortex has been cut away to show the axis, *ax*, and the longitudinal canals, *lc*, surrounding it.

The AXIFERA comprises those corals that have a horny or calcified axis, which in position corresponds to the axis of the Pseudaxonia, but, unlike it, is never formed of fused spicules; the most familiar example is the pink sea-fan, *Gorgonia Cavolinii*, which is found in abundance in 10-25 fathoms of water off the English coasts (Fig. 7). In this order the axis is formed as an ingrowth of the ectoderm of the base of the mother zooid of the colony, the cavity of the ingrowth being filled by a horny substance secreted by the ectoderm. In *Gorgonia* the axis remains horny throughout life, but in many forms it is further strengthened by a deposit of calcareous matter. In the family *Isidinæ* the axis consists of alternate segments of horny and calcareous substance, the latter being amorphous. The order contains six families—the *Dasygorgidæ*, *Isidæ*, *Primnoidæ*, *Muriceidæ*, *Plexauridæ*, and *Gorgonidæ*.

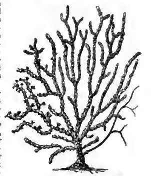


FIG. 7.—The sea-fan (*Gorgonia Cavolinii*).

In the order STELECHOTOKEA the colony consists of a stem formed by a greatly-elongated mother zooid, and the daughter zooids are borne as lateral buds on the stem. In the section *Asiphonacea* the colonies are upright and branched, springing from membranous or ramifying stolons. They resemble and are closely allied to certain families of the Cornulariidæ, differing from them only in mode of budding and in the disposition of the daughter zooids round a central, much-elongated mother zooid. The section contains two families, the *Telestidæ* and the *Cœlogorgidæ*. The second section comprises the *Pennatulacea* or sea-pens, which are remarkable from the fact that the colony is not fixed by the base to a rock or other object, but is imbedded in sand or mud by the proximal portion of the stem known as the peduncle. In the typical

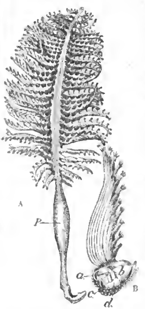


FIG. 8.—A, Colony of *Pennatula phosphorea* from the metarachidial aspect. *p*, the peduncle. B, Section of the rachis bearing a single pinna. *a*, axis; *b*, metarachidial, *c*, prorachidial, *d*, pararachidial stem canals.

genus, Pennatula (Fig. 8), the colony looks like a feather having a stem, divisible into an upper moiety or rachis, bearing lateral central leaflets (pinnæ), and a lower peduncle, which is sterile and imbedded in sand or mud. The stem represents a greatly enlarged and elongated mother zooid. It is divided longitudinally by a partition separating a so-called "ventral" or prorachidial canal from a so-called "dorsal" or metarachidial canal. A rod-like supporting axis of peculiar texture is developed in the longitudinal partition, and a longitudinal canal is hollowed out on either side of the axis in the substance of the longitudinal partition, so that there are four stem-canals in all. The prorachidial and metarachidial aspects of the rachis are sterile, but the sides or pararachides bear numerous daughter zooids of two kinds—(1) fully-formed autozooids, (2) small stunted siphonozooids. The pinnæ are formed by the elongated autozooids, whose proximal portions are fused together to form a leaf-like expansion, from the upper edge of which the distal extremities of the zooids project. The siphonozooids are very numerous and lie between the bases of the pinnæ on the pararachides; they extend also on the prorachidial and metarachidial surfaces. The calcareous skeleton of the Pennatulacea consists of scattered spicules, but in one species, *Protocaulon molle*, spicules are absent. Although of great interest the Pennatulacea do not form an enduring skeleton or "coral," and need not be considered in detail in this place.

The order CŒNOTHECALIA is represented by a single living species, *Heliopora cærulea*, which differs from all recent Alcyonaria in the fact that its skeleton is not composed of spicules, but is formed as a secretion from a layer of cells called calicoblasts, which originate from the ectoderm. The corallum of Heliopora is of a blue colour, and has the form of broad, upright, lobed, or digitate masses flattened from side to side. The surfaces are pitted all over with perforations of two kinds, viz., larger star-shaped cavities, called *calices*, in which the zooids are lodged, and very numerous smaller round or polygonal apertures, which in life contain as many short unbranched tubes, known as the *cœnenchymal tubes* (Fig. 9, A). The walls of the calices and cœnenchymal tubes are formed of flat plates of calcite, which are so disposed that the walls of one tube enter into the composition of the walls of adjacent tubes, and the walls of the calices are formed by the walls of adjacent cœnenchymal tubes. Thus the architecture of the Helioporid colony differs entirely from such forms as Tubipora or Favosites, in which each corallite has its own distinct and proper wall. The cavities both of the calices and cœnenchymal tubes of Heliopora are closed below by horizontal partitions or *tabulæ*, hence the genus was formerly included in the group Tabulata, and was supposed to belong to the madreporarian corals, both because of its lamellar skeleton, which resembles that of a Madrepore, and because each calicle has from twelve to fifteen radial partitions or septa projecting into its cavity. The structure of the zooid of Heliopora, however, is that of a typical Alcyonarian, and the septa have only a resemblance to, but no real homology with, the similarly-named structures in madreporarian corals. *Heliopora cærulea* is found between tide-marks on the shore platforms of coral islands. The order was more abundantly represented in Palæozoic times by the Heliolitidæ from the Upper and Lower Silurian and the Devonian, and by the Thecidæ from the Wenlock limestone. In *Heliolites porosus* the colonies had the form of spheroidal masses; the calices were furnished with twelve pseudosepta, and the cœnenchymal tubes were more or less regularly hexagonal.

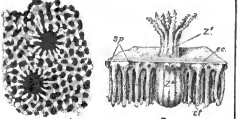


FIG. 9.—A, Portion of the surface of a colony of *Heliopora cærulea* magnified, showing two calices and the surrounding cœnenchymal tubes. B, Single zooid with the adjacent soft tissues as seen after removal of the skeleton by decalcification. Z^1, the distal, and Z^2, the proximal or intracalicular portion of the zooid; *ec*, ectoderm; *ct*, cœnenchymal tubes; *sp*, superficial network of solenia.

Zoantharia.—In this sub-class the arrangement of the mesenteries is subject to a great deal of variation, but all the types hitherto observed may be referred to a common plan, illustrated by the living genus *Edwardsia* (Fig. 10, A, B). This is a small solitary Zoantharian which lives embedded in sand. Its body is divisible into three portions, an upper *capitulum* bearing the mouth and tentacles, a median *scapus* covered by a friable cuticle, and a terminal *physa* which is rounded. Both capitulum and physa can be retracted within the scapus. There are from sixteen to thirty-two simple tentacles, but only eight mesenteries, all of which are complete. The stomodæum is compressed laterally, and is furnished with two longitudinal grooves, a sulcus and a sulculus. The arrangement of the muscle-banners on the mesenteries is characteristic. On six of the mesenteries the muscle-banners have the same position as in the Alcyonaria, namely, on the sulcar faces; but in the two remaining mesenteries, namely, those which are attached on either side of the sulcus, the muscle-banners are on the opposite or sulcular faces. It is not known whether all the eight mesenteries of *Edwardsia* are developed simultaneously or not, but in the youngest form which has been studied all the eight mesenteries were present, but only two of them, namely the sulco-laterals, bore mesenterial filaments, and so it is presumed that they are the first pair to be developed. In the common sea-anemone, *Actinia equina* (which has already been quoted as a type of Anthozoan structure), the mesenteries are numerous and are arranged in cycles. The mesenteries of the first cycle are complete (*i.e.*, are attached to the stomodæum), are twelve in number, and arranged in couples, distinguishable by the position of the muscle-banners. In the four couples of mesenteries which are attached to the sides of the elongated stomodæum the muscle-banners of each couple are turned towards one another, but in the sulcar and sulcular couples, known as the directive mesenteries, the muscle-banners are on the outer faces of the mesenteries, and so are turned away from one another (see Fig. 10, C). The space enclosed between two mesenteries of the same couple is called an *entocœle;* the space enclosed between two mesenteries of adjacent couples is called an *exocœle*. The second cycle of mesenteries consists of six couples, each formed in an exocœle of the primary cycle, and in each couple the muscle-banners are *vis-à-vis*. The third cycle comprises twelve couples, each formed in an exocœle between the primary and secondary couples, and so on, it being a general rule (subject, however, to exceptions) that new mesenterial couples are always formed in the exocœles, and not in the entocœles.

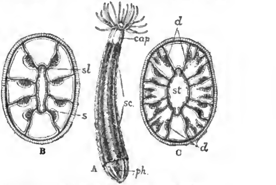


FIG. 10.—A, *Edwardsia claparedii* (after A. Andres). *cap*, capitulum; *sc*, scapus; *ph*, physa. B, Transverse section of the same, showing the arrangement of the mesenteries. *s*, sulcus; *sl*, sulculus. C, Transverse section of *Halcampa*. *d*, *d*, directive mesenteries; *st*, stomodæum.

While the mesenterial couples belonging to the second and each successive cycle are formed simultaneously, those of the first cycle are formed in successive pairs, each member of a pair being placed on opposite sides of the stomodæum. Hence the arrangement in six couples is a secondary and not a primary feature. In most Actinians the mesenteries appear in the following order:—At the time when the stomodæum is formed, a single pair of mesenteries, marked I, I in the diagram (Fig. 11, A), makes its appearance, dividing the cœlenteric cavity into a smaller sulcar and a large sulcular chamber. The muscle-banners of this pair are placed on the sulcar faces of the mesenteries. Next, a pair of mesenteries, marked II, II in the diagram, is developed in the sulcular chamber, its muscle-banners facing the same way as those of I, I. The third pair is formed in the sulcar chamber, in close connexion with the sulcus, and in this case the muscle-banners are on the *sulcular* faces. The fourth pair, having its muscle-banners on the sulcar faces, is developed at the opposite extremity of the stomodæum in close connexion with the sulculus. There are now eight mesenteries present, having exactly the same arrangement as in Edwardsia. A pause in the development follows, during which no new mesenteries are formed, and then the six-rayed symmetry characteristic of a normal Actinian zooid is completed by the formation of the mesenteries V, V in the lateral chambers, and VI, VI in the sulco-lateral chambers, their muscle-banners being so disposed that they form couples respectively with II, II and I, I. In *Actinia* *equina* the Edwardsia stage is arrived at somewhat differently. The mesenteries second in order of formation form the sulcular directives, those fourth in order of formation form with the fifth the sulculo-lateral couples of the adult.

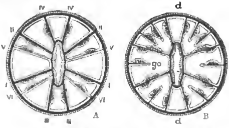


Fig. 11.—A, Diagram showing the sequence of mesenterial development in an Actinian. B, Diagrammatic transverse section of *Gonactinia prolifera*.

As far as the anatomy of the zooid is concerned, the majority of the stony or madreporarian corals agree exactly with the soft-bodied Actinians, such as *Actinia equina*, both in the number and arrangement of the adult mesenteries and in the order of development of the first cycle. The few exceptions will be dealt with later, but it may be stated here that even in these the first cycle of six couples of mesenteries is always formed, and in all the cases which have been examined the course of development described above is followed. There are, however, several groups of Zoantharia in which the mesenterial arrangement of the adult differs widely from that just described. But it is possible to refer all these cases with more or less certainty to the Edwardsian type.

The order ZOANTHIDEA comprises a number of soft-bodied Zoantharians generally encrusted with sand. Externally they resemble ordinary sea-anemones, but there is only one ciliated groove, the sulcus, in the stomodæum, and the mesenteries are arranged on a peculiar pattern. The first twelve mesenteries are disposed in couples, and do not differ from those of Actinia except in size. The mesenterial pairs I, II, and III are attached to the stomodæum, and are called macromesenteries (Fig. 12, B), but IV, V, and VI are much shorter, and are called micromesenteries. The subsequent development is peculiar to the group. New mesenteries are formed only in the sulco-lateral exocœles. They are formed in couples, each couple consisting of a macromesentery and a micromesentery, disposed so that the former is nearest to the sulcar directives. The derivation of the Zoanthidea from an Edwardsia form is sufficiently obvious.

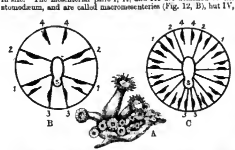


Fig. 12.—A, Zoanthid colony, showing the expanded zooids. B, Diagram showing the arrangement of mesenteries in a young Zoanthid. C, Diagram showing the arrangement of mesenteries in an adult Zoanthid. 1, 2, 3, 4, Edwardsian mesenteries.

The order CERIANTHIDEA comprises a few soft-bodied Zoantharians with rounded aboral extremities pierced by pores. They have two circlets of tentacles, a labial and a marginal, and there is only one ciliated groove in the stomodæum, which appears to be the sulculus. The mesenteries are numerous, and the longitudinal muscles, though distinguishable, are so feebly developed that there are no muscle-banners. The larval forms of the type genus *Cerianthus* float freely in the sea, and were once considered to belong to a separate genus, *Arachnactis*. In this larva four pairs of mesenteries having the typical Edwardsian arrangement are developed, in the same sequence as in Rhodactis, but the fifth and sixth pairs, instead of forming couples with the first and second, arise in the sulcar chamber, the fifth pair inside the fourth, and the sixth pair inside the fifth. New mesenteries are continually added in the sulcar chamber, the seventh pair within the sixth, the eighth pair within the seventh, and so on (Fig. 13). In the Cerianthidea, as in the Zoanthidea, much as the adult arrangement of mesenteries differs from that of Actinia, the derivation from an Edwardsia stock is obvious.

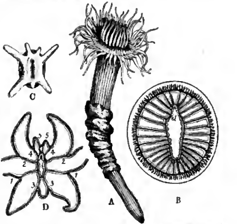


Fig. 13.—A, *Cerianthus solitarius* (after A. Andres). B, Transverse section of the stomodæum, showing the sulculus, *sl*, and the arrangement of the mesenteries. C, Oral aspect of *Arachnactis brachiolata*, the larva of Cerianthus, with seven tentacles. D, Transverse section of an older larva. The numerals indicate the order of development of the mesenteries.

The order ANTIPATHIDEA is a well-defined group whose affinities are more obscure. The type form, *Antipathes dichotoma* (Fig. 14), forms arborescent colonies consisting of numerous zooids arranged in a single series along one surface of a branched horny axis. Each zooid has six tentacles; the stomodæum is elongate, but the sulcus and sulculus are very feebly represented. There are ten mesenteries in which the musculature is so little developed as to be almost indistinguishable. The sulcar and sulcular pairs of mesenteries are short, the sulco-lateral and sulculo-lateral pairs are a little longer, but the two transverse are very large and are the only mesenteries which bear gonads. As the development of the Antipathidea is unknown, it is impossible to say what is the sequence of the mesenterial development, but in *Leiopathes glaberrima*, a genus with twelve mesenteries, there are distinct indications of an Edwardsia stage.

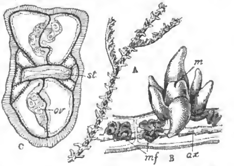


Fig. 14.—A, Portion of a colony of *Antipathes dichotoma*. B, Single zooid and axis of the same magnified. *m*, mouth; *mf*, mesenterial filament; *ax*, axis. C, Tranverse section through the oral cone of *Antipathella minor*. *st*, stomodæum; *ov*, ovary.

There are, in addition to these groups, several genera of Actinians whose mesenterial arrangement differs from the normal type. Of these perhaps the most interesting is *Gonactinia prolifera* (Fig. 11, B), with eight macromesenteries arranged on the Edwardsian plan. Two pairs of micromesenteries form couples with the first and second Edwardsian pairs, and in addition there is a couple of micromesenteries in each of the sulculo-lateral exocœles. Only the first and second pairs of Edwardsian macromesenteries are fertile, *i.e.*, bear gonads.

The remaining forms, the ACTINIIDEA, are divisible into the Malacactiniæ, or soft-bodied sea-anemones, which have already been described sufficiently in the course of this article (pp. 454-5), and the Scleractiniæ (= Madreporaria), or true corals.

All recent corals, as has already been said, conform so closely to the anatomy of normal Actinians that they cannot be classified apart from them, except that they are distinguished by the possession of a calcareous skeleton. This skeleton is largely composed of a number of radiating plates or *septa*, and it differs both in origin and structure from the calcareous skeleton of all Alcyonaria except Heliopora. It is formed, not from fused spicules, but as a secretion of a special layer of cells derived from the basal ectoderm, and known as *calicoblasts*. The skeleton or corallum of a typical solitary coral—the common Devonshire cup-coral *Caryophyllia Smithii* (Fig. 15) is a good example—exhibits the following parts:—(1) The *basal plate*, between the zooid and the surface of attachment. (2) The *septa*, radial plates of calcite reaching from the periphery nearly or quite to the centre of the coral-cup or calicle. (3) The *theca* or wall, which in many corals is not an independent structure, but is formed by the conjoined thickened peripheral ends of the septa. (4) The *columella*, a structure which occupies the centre of the calicle, and may arise from the basal plate, when it is called essential, or may be formed by union of trabecular offsets of the septa, when it is called unessential. (5) The *costæ*, longitudinal ribs or rows of spines on the outer surface of the theca. True costæ always correspond to the septa, and are in fact the peripheral edges of the latter. (6) *Epitheca*, an offset of the basal plate which surrounds the base of the theca in a ring-like manner, and in some corals may take the place of a true theca. (7) *Pali*, spinous or blade-like upgrowths from the bottom of the calicle, which project between the inner edges of certain septa and the columella. In addition to these parts the following structures may exist in corals:—*Dissepiments* are oblique calcareous partitions, stretching from septum to septum, and closing the interseptal chambers below. The whole system of dissepiments in any given calicle is often called *endotheca*. *Synapticulæ* are calcareous bars uniting adjacent septa. *Tabulæ* are stout horizontal partitions traversing the centre of the calicle and dividing it into as many superimposed chambers. The septa in recent corals always bear a definite relation to the mesenteries, being found either in every entocœle or in every entocœle and exocœle. Hence in corals in which there is only a single cycle of mesenteries the septa are correspondingly few in number; where several cycles of mesenteries are present the septa are correspondingly numerous. In some cases—*e.g.*, in some species of *Madrepora*—only two septa are fully developed, the remainder being very feebly represented.

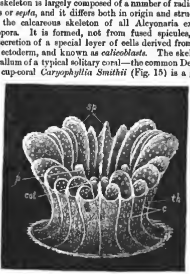


FIG. 15.—Corallum of Caryophyllia; semi-diagrammatic. *th*, theca; *c*, costæ; *sp*, septa; *p*, palus; *col*, columella.

Though the corallum appears to lie within the zooid, it is morphologically external to it, as is best shown by its developmental history. The larvæ of corals are free swimming ciliated forms known as planulæ, and they do not acquire a corallum until they fix themselves. A ring-shaped plate of calcite, secreted by the ectoderm, is then formed, lying between the embryo and the surface of attachment. As the mesenteries are formed, the endoderm of the basal disc lying above the basal plate is raised up in the form of radiating folds. There may be six of such folds, one in each entocœle of the primary cycle of mesenteries; or there may be twelve, one in each exocœle and entocœle. The ectoderm beneath each fold becomes detached from the surface of the basal plate, and both it and the mesoglœa are folded conformably with the endoderm. The cells forming the limbs of the ectodermic folds secrete nodules of calcite, and these, fusing together, give rise to six (or twelve) vertical radial plates or septa. As growth proceeds new septa are formed simultaneously with the new couples of secondary mesenteries. In some corals, in which all the septa are entocœlic, each new system is embraced by a mesenteric couple; in others, in which the septa are both entocœlic and exocœlic, three septa are formed in every chamber between two primary mesenterial couples, one in the entocœle of the newly-formed mesenterial couple of the secondary cycle, and one in each exocœle between a primary and a secondary couple. These latter are in turn embraced by the couples of the tertiary cycle of mesenteries, and new septa are formed in the exocœles on either side of them, and so forth.

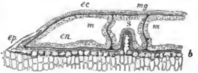


FIG. 16.—Tangential section of a larva of *Astroides calicularis* which has fixed itself on a piece of cork. *ec*, ectoderm; *en*, endoderm; *mg*, mesoglœa; *m*, *m*, mesenteries; *s*, septum; *b*, basal plate formed of ellipsoids of carbonate of lime secreted by the basal ectoderm; *ep*, epitheca. (After von Koch.)

It is evident from an inspection of Figs. 16 and 17 that every septum is covered by a fold of endoderm, mesoglœa, and ectoderm, and is in fact pushed into the cavity of the zooid from without. The zooid then is, as it were, moulded upon the corallum. When fully extended, the upper part of the zooid projects for some distance out of the calicle, and its wall is reflected for some distance over the lip of the latter, forming a fold of soft tissue extending to a greater or less distance over the theca, and containing in most cases a cavity continuous over the lip of the calicle with the cœlenteron. This fold of tissue is known as the *edge-zone*. In some corals the septa are solid imperforate plates of calcite, and their peripheral ends are either firmly welded together, or are united by interstitial pieces so as to form an imperforate theca. In others the peripheral ends of the septa are united only by bars or trabeculæ, so that the theca is perforate, and in many such perforate corals the septa themselves are pierced by numerous perforations. In the former, which have been called aporose corals, the only communication between the cavity of the edge-zone and the general cavity of the zooid is by way of the lip of the calicle; in the latter, or perforate corals, the theca is permeated by numerous branching and anastomosing canals lined by endoderm, which place the cavity of the edge-zone in communication with the general cavity of the zooid.

A large number of corals, both aporose and perforate, are colonial. The colonies are produced either by budding or division. In the former case the young daughter zooid, with its corallum, arises wholly outside the cavity of the parent zooid, and the component parts of the young corallum, septa, theca, columella, &c., are formed anew in every individual produced. In division a vertical constriction divides a zooid into two equal or unequal parts, and the several parts of the two corals thus produced are severally derived from the corresponding parts of the dividing corallum. In colonial corals a bud is always formed from the edge-zone, and this bud develops into a new zooid with its corallum. The cavity of the bud in an aporose coral (Fig. 18, A, C) does not communicate directly with that of the parent form, but through the medium of the edge-zone. As growth proceeds, and parent and bud become separated farther from one another, the edge-zone forms a sheet of soft tissue, bridging over the space between the two, and resting upon projecting spines of the corallum. This sheet of tissue is called the *cœnosarc*. Its lower surface is clothed with a layer of calicoblasts which continue to secrete carbonate of lime, giving rise to a secondary deposit which more or less fills up the spaces between the individual coralla, and is distinguished as *cœnenchyme*. This cœnenchyme may be scanty, or may be so abundant that the individual corallites produced by budding seem to be immersed in it. Budding takes place in an analogous manner in perforate corals (Fig. 18, B), but the presence of the canal system in the perforate theca leads to a modification of the process. Buds arise from the edge-zone which already communicate with the cavity of the zooid by the canals. As the buds develop the canal system becomes much extended, and calcareous tissue is deposited between the network of canals, the confluent edge-zones of mother zooid and bud forming a cœnosarc. As the process continues a number of calicles are formed, imbedded in a spongy tissue in which the canals ramify, and it is impossible to say where the theca of one corallite ends and that of another begins. In the formation of colonies by division a constriction at right angles to the long axis of the mouth involves first the mouth, then the peristome, and finally the calyx itself, so that the previously single corallite becomes divided into two (Fig. 18, E). After division the corallites continue to grow upwards, and their zooids may remain united by a bridge of soft tissue or cœnosarc. But in some cases as they grow farther apart, this continuity is broken, each corallite has its own edge-zone, and internal continuity is also broken by the formation of dissepiments within each calicle, all organic connexion between the two zooids being eventually lost. Massive meandrine corals are produced by continual repetition of a process of incomplete division, involving the mouth and to some extent the peristome: the calyx, however, does not divide, but elongates to form a characteristic meandrine channel containing several zooid mouths.

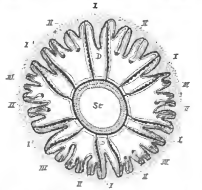


FIG. 17.—Transverse section through a zooid of *Cladocora*. The corallum shaded with dots, the mesoglœa represented by a thick line. Thirty-two septa are present, six in the entocœles of the primary cycle of mesenteries, I; six in the entocœles of the secondary cycle of mesenteries, II; four in the entocœles of the tertiary cycle of mesenteries, III, only four pairs of the latter being developed; and sixteen in the entocœles between the mesenterial pairs. *D*, *D*, directive mesenteries; *st*, stomodæum. (After Duerden.)

Corals have been divided into *Aporosa* and *Perforata*, according as the theca and septa are compact and solid, or are perforated by pores containing canals lined by endoderm. The division is in many respects convenient for descriptive purposes, but recent researches show that it does not accurately represent the relationships of the different families. Various attempts have been made to classify corals according to the arrangement of the septa, the characters of the theca, the microscopic structure of the corallum, and the anatomy of the soft parts. The last-named method has proved little more than that there is a remarkable similarity between the zooids of all recent corals, the differences which have been brought to light being for the most part secondary and valueless for classificatory purposes. On the other hand, the study of the anatomy and development of the zooids has thrown much light upon the manner in which the corallum is formed, and it is now possible to infer the structure of the soft parts from a microscopical examination of the septa, theca, &c., with the result that unexpected relationships have been shown to exist between corals previously supposed to stand far apart. This has been particularly the case with the group of Palæozoic corals formerly classed together as *Rugosa*. In many of these so-called rugose forms the septa have a characteristic arrangement, differing from that of recent corals chiefly in the fact that they show a tetrameral instead of a hexameral symmetry. Thus in the family *Stauridæ* there are four chief septa whose inner ends unite in the middle of the calicle to form a false columella, and in the *Zaphrentidæ* there are many instances of an arrangement, such as that depicted in Fig. 19, which represents the

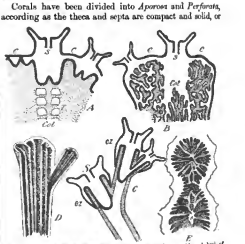


FIG. 18.—A, Schematic longitudinal section through a zooid and bud of *Stylophora digitata*. In A, B, and C the thick black lines represent the soft tissues; the corallum is dotted. *s*, stomodæum; *c*, *c*, cœnosarc; *col*, columella; *T*, tabulæ. B, Similar section through a single zooid and bud of *Astroides calicularis*. C, Similar section through three corallites of *Lophohelia prolifera*. *ez*, edge-zone. D, Diagram illustrating the process of budding by unequal division. E, Section through a dividing calicle of *Mussa*, showing the union of two septa in the plane of division, and the origin of new septa at right angles to them. (C, original; the rest after von Koch.)

septal arrangement of *Streptelasma corniculum* from the lower Silurian. In this coral the calicle is divided into quadrants by four principal septa, the *main septum*, *counter septum*, and two *alar septa*. The remaining septa are so disposed that in the quadrants abutting on the chief septum they converge towards that septum, whilst in the other quadrants they converge towards the alar septa. The secondary septa show a regular gradation in size, and, assuming that the smallest were the most recently formed, it will be noticed that in the chief quadrants the youngest septa lie nearest to the main septum; in the other quadrants the youngest septa lie nearest to the alar septa. This arrangement, however, is by no means characteristic even of the Zaphrentidæ, and in the family *Cyathophyllidæ* most of the genera exhibit a radial symmetry in which no trace of the bilateral arrangement described above is recognizable, and indeed in the genus *Cyathophyllum* itself a radial arrangement is the rule. The connexion between the Cyathophyllidæ and modern Astræidæ is shown by *Moseleya latistellata*, a living reef-building coral from Torres Strait. The general structure of this coral leaves no doubt that it is closely allied to the Astræidæ, but in the young calicles a tetrameral symmetry is indicated by the presence of four large septa placed at right angles to one another. Again, in the family *Amphiastræidæ* there is commonly a single septum much larger than the rest, and it has been shown that in the young calicles, *e.g.*, of *Thecidiosmilia*, two septa, corresponding to the main- and counter-septa of Streptelasma, are first formed, then two alar septa, and afterwards the remaining septa, the latter taking on a generally radial arrangement, though the original bilaterality is marked by the preponderance of the main septum. As the microscopic character of the corallum of these extinct forms agrees with that of recent corals, it may be assumed that the anatomy of the soft parts also was similar, and the tetrameral arrangement, when present, may obviously be referred to a stage when only the first two pairs of Edwardsian mesenteries were present and septa were formed in the intervals between them.

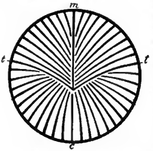


Fig. 19.—Diagram of the arrangement of the septa in a Zaphrentid coral. m, main septum; c, counter septum; t, t, alar septa.

Space forbids a discussion of the proposals to classify corals after the minute structure of their coralla, but it will suffice to say that it has been shown that the septa of all corals are built up of a number of curved bars called trabeculæ, each of which is composed of a number of nodes. In many secondary corals (*Cyclolites*, *Thamnastræa*) the trabeculæ are so far separate that the individual bars are easily recognizable, and each looks something like a bamboo owing to the thickening of the two ends of each node. The trabeculæ are united together by these thickened internodes, and the result is a fenestrated septum, which in older septa may become solid and aporose by continual deposit of calcite in the fenestræ. Each node of a trabecula may be simple—*i.e.*, have only one centre of calcification, or may be compound. The septa of modern perforate corals are shown to have a structure nearly identical with that of the secondary forms, but the trabeculæ and their nodes are only apparent on microscopical examination. The aporose corals, too, have a practically identical structure, their compactness being due to the union of the trabeculæ throughout their entire lengths instead of at intervals, as in the Perforata. Further, the trabeculæ may be evenly spaced throughout the septum, or may be grouped together, and this feature is probably of value in estimating the affinities of corals.

In the present state of our knowledge the Zoantharia, in which a primary cycle of six couples of mesenteries is (or may be inferred to be) completed by the addition of two pairs to the eight Edwardsian mesenteries, and succeeding cycles are formed in the exocœles of the pre-existing mesenterial cycles, may be classed in an order Actiniidea, and this may be divided into the sub-orders *Malacactiniæ*, comprising the soft-bodied Actinians, such as *Actinia*, *Sagartia*, *Bunodes*, &c., and the *Scleractiniæ*, comprising the corals. The Scleractiniæ may best be divided into groups of families which appear to be most closely related to one another, but it should not be forgotten that there is great reason to believe that many if not most of the extinct corals must have differed from modern Actiniidea in mesenterial characters, and may have only possessed Edwardsian mesenteries, or even have possessed only four mesenteries, in this respect showing close affinities to the Stauromedusæ. Moreover, there are some modern corals in which the secondary cycle of mesenteries departs from the Actinian plan. For example, Duerden has shown that in *Porites* the ordinary zooids possess only six couples of mesenteries arranged on the Actinian plan. But some zooids grow to a larger size and develop a number of additional mesenteries, which arise either in the sulcar or the sulcular entocœle, much in the same manner as in Cerianthus. Bearing this in mind, the following arrangement may be taken to represent the most recent knowledge of coral structure:—

Group A.

Family 1. Zaphrentidæ.—Solitary Palæozoic corals with an epithecal wall. Septa numerous, arranged pinnately with regard to four principal septa. Tabulæ present. One or more pits or fossulæ present in the calicle. Typical genera—*Zaphrentis*, Raf. *Amplexus*, M. Edw. and H. *Streptelasma*, Hall. *Omphyma*, Raf.

Family 2. Turbinolidæ.—Solitary, rarely colonial corals, with radially arranged septa and without tabulæ. Typical genera—*Flabellum*, Lesson. *Turbinolia*, M. Edw. and H. *Caryophyllia*, Lamarck. *Sphenotrochus*, Moseley, &c.

Family 3. Amphiastræidæ.—Mainly colonial, rarely solitary corals, with radial septa, but bilateral arrangement indicated by persistence of a main septum. Typical genera—*Amphiastræa*, Etallon. *Thecidiosmilia*.

Family 4. Stylinidæ.—Colonial corals allied to the Amphiastræidæ, but with radially symmetrical septa arranged in cycles. Typical genera—*Stylina*, Lamarck (Jurassic). *Convexastræa*, D'Orb. (Jurassic). *Isastræa*, M. Edw. and H. (Jurassic). Ogilvie refers the modern genus *Galaxea* to this family.

Group B.

Family 5. Oculinidæ.—Branching or massive aporose corals, the calices projecting above the level of a compact cœnenchyme formed from the cœnosarc which covers the exterior of the corallum. Typical genera—*Lophohelia*, M. Edw. and H. *Oculina*, M. Edw. and H.

Family 6. Pocilloporidæ.—Colonial branching aporose corals, with small calices sunk in the cœnenchyme. Tabulæ present, and two larger septa, an axial and abaxial, are always present, with traces of ten smaller septa. Typical genera—*Pocillopora*, Lamarck. *Seriatopora*, Lamarck.

Family 7. Madreporidæ.—Colonial branching or palmate perforate corals, with abundant trabecular cœnenchyme. Theca porous; septa compact and reduced in number. Typical genera—*Madrepora*, Linn. *Turbinaria*, Oken. *Montipora*, Quoy and G.

Family 8. Poritidæ.—Incrusting or massive colonial perforate corals; calices usually in contact by their edges, sometimes disjunct and immersed in cœnenchyme. Theca and septa perforate. Typical genera—*Porites*, M. Edw. and H. *Goniopora*, Quoy and G. *Rhodaræa*, M. Edw. and H.

Group C.

Family 9. Cyathophyllidæ.—Solitary and colonial aporose corals. Tabulæ and vesicular endotheca present. Septa numerous, generally radial, seldom pinnate. Typical genera—*Cyathophyllum*, Goldfuss (Devonian and Carboniferous). *Moseleya*, Quelch (recent).

Family 10. Astræidæ.—Aporose, mainly colonial corals, massive, branching, or mæandroid. Septa radial; dissepiments present; an epitheca surrounds the base of massive or mæandroid forms, but only surrounds individual corallites in simple or branching forms. Typical genera—*Goniastræa*, M. Edw. and H. *Heliastræa*, M. Edw. and H. *Mæandrina*, Lam. *Cœloria*, M. Edw. and H. *Favia*, Oken.

Family 11. Fungidæ.—Solitary and colonial corals, with numerous radial septa united by synapticulæ. Typical genera—*Lophoseris*, M. Edw. and H. *Thamnastræa*, Le Sauvage. *Leptophyllia*, Reuss (Jurassic and Cretaceous). *Fungia*, Dana. *Siderastræa*, Blainv.

Group D.

Family 12. Eupsammidæ.—Solitary or colonial perforate corals, branching, massive, or encrusting. Septa radial; the primary septa usually compact, the remainder perforate. Theca perforate. Synapticula present in some genera. Typical genera—*Stephanophyllia*, Michelin. *Eupsammia*, M. Edw. and H. *Astroides*, Blainv. *Rhodopsammia*, M. Edw. and H. *Dendrophyllia*, M. Edw. and H.

Group E.

Family 13. Cystiphyllidæ.—Solitary corals with rudimentary septa, and the calicle filled with vesicular endotheca. Genera—*Cystiphyllum*, Lonsdale (Silurian and Devonian). *Goniophyllum*, M. Edw. and H. (In this Silurian genus the calyx is provided with a movable operculum, consisting of four paired triangular pieces, the bases of each being attached to the sides of the calyx, and their apices meeting in the middle when the operculum is closed). *Calceola*, Lam. (In this Devonian genus there is a single semicircular operculum furnished with a stout median septum and numerous feebly developed secondary septa. The calyx is triangular in section, pointed below, and the operculum is attached to it by hinge-like teeth.)

Coral formations.

Many species of corals are widely distributed, and are found at all depths both in warmer and colder seas. ***Lophohelia prolifera*** and ***Dendrophyllia ramea*** form dense beds at a depth of from 100 to 200 fathoms off the coasts of Norway, Scotland, and Portugal, and the *Challenger* and other deep-sea dredging expeditions have brought up corals from great depths in the Pacific and Atlantic oceans. But the larger number of species, particularly the more massive kinds, occur only in tropical seas in shallow waters, whose mean temperature does not fall below 68° Fahr., and they do not flourish unless the temperature is considerably higher. These conditions of temperature are found in a belt of ocean which may roughly be indicated as lying between the 28th N. and S. parallels. Within these limits there are numerous reefs and islands formed of coral intermixed with the calcareous skeletons of other animals, and their formation has long been a matter of dispute among naturalists and geologists.

Coral formations may be classed as fringing or shore reefs, barrier reefs, and atolls. *Fringing reefs* are platforms of coral rock extending no great distance from the shores of a continent or island. The seaward edge of the platform is usually somewhat higher than the inner part, and is often awash at low water. It is intersected by numerous creeks and channels, especially opposite those places where streams of fresh water flow down from the land, and there is usually a channel deep enough to be navigable by small boats between the edge of the reef and the land. The outer wall of the reef is rather steep, but descends into a comparatively shallow sea. Since corals are killed by fresh water or by deposition of mud or sand, it is obvious that the outer edge of the reef is the region of most active coral growth, and the boat channel and the passages leading into it from the open sea have been formed by the suppression of coral growth by one of the above-mentioned causes, assisted by the scour of the tides and the solvent action of sea-water. *Barrier reefs* may be regarded as fringing reefs on a large scale. The great Australian barrier reef extends for no less a distance than 1250 miles from Torres Strait in 9·5° S. lat. to Lady Elliot island in 24° S. lat. The outer edge of a barrier reef is much farther from the shore than that of a fringing reef, and the channel between it and the land is much deeper. Opposite Cape York the seaward edge of the great Australian barrier reef is nearly 90 miles distant from the coast, and the maximum depth of the channel at this point is nearly 20 fathoms. As is the case in a fringing reef, the outer edge of a barrier reef is in many places awash at low tides, and masses of dead coral and sand may be piled up on it by the action of the waves, so that islets are formed which in time are covered with vegetation. These islets may coalesce and form a strip of dry land lying some hundred yards or less from the extreme outer edge of the reef, and separated by a wide channel from the mainland. Where the barrier reef is not far from the land there are always gaps in it opposite the mouths of rivers or considerable streams. The outer wall of a barrier reef is steep, and frequently, though not always, descends abruptly into great depths. In many cases in the Pacific Ocean a barrier reef surrounds one or more island peaks, and the strip of land on the edge of the reef may encircle the peaks with a nearly complete ring. An *atoll* is a ring-shaped reef, either awash at low tide or surmounted by several islets, or more rarely by a complete strip of dry land surrounding a central lagoon. The outer wall of an atoll generally descends with a very steep but irregular slope to a depth of 500 fathoms or more, but the lagoon is seldom more than 20 fathoms deep, and may be much less. Frequently, especially to the leeward side of an atoll, there may be one or more navigable passages leading from the lagoon to the open sea.

Though corals flourish everywhere under suitable conditions in tropical seas, coral reefs and atolls are by no means universal in the torrid zone. The Atlantic Ocean is remarkably free from coral formations, though there are numerous reefs in the West Indian islands, off the south coast of Florida, and on the coast of Brazil. The Bermudas also are coral formations, their high land being formed by sand accumulated by the wind and cemented into rock, and are remarkable for being the farthest removed from the equator of any recent reefs, being situated in 32° N. lat. In the Pacific Ocean there is a vast area thickly dotted with coral formations, extending from 5° N. lat. to 25° S. lat., and from 130° E. long. to 145° W. long. There are also extensive reefs in the westernmost islands of the Hawaiian group in about 25° N. lat. In the Indian Ocean, the Laccadive and Maldive islands are large groups of atolls off the west and south-west of India. Still farther south is the Chagos group of atolls, and there are numerous reefs off the north coast of Madagascar, at Mauritius, Bourbon, and the Seychelles. The Cocos-Keeling Islands, in 12° S. lat. and 96° E. long., are typical atolls in the eastern part of the Indian Ocean.

The remarkable characters of barrier reefs and atolls, their isolated position in the midst of the great oceans, the seemingly unfathomable depths from which they rise, their peaceful and shallow lagoons and inner channels, their narrow strips of land covered with cocoa-nut palms and other vegetation, and rising but a few feet above the level of the ocean, naturally attracted the attention of the earlier navigators, who formed sundry speculations as to their origin. The poet-naturalist Chamisso was the first to propound a definite theory of the origin of atolls and encircling reefs, attributing their peculiar features to the natural growth of corals and the action of the waves. He pointed out that the larger and more massive species of corals flourish best on the outer sides of a reef, whilst the more interior corals are killed or stunted in growth by the accumulation of coral and other debris. Thus the outer edge of a submerged reef is the first to reach the surface, and a ring of land being formed by materials piled up by the waves, an atoll with a central lagoon is produced. Chamisso's theory necessarily assumed the existence of a great number of submerged banks reaching nearly, but not quite, to the surface of the sea in the Pacific and Indian oceans, and the difficulty of accounting for the existence of so many of these led Darwin to reject his views and bring forward an explanation which may be called the theory of *subsidence*. Starting from the well-known premiss that reef-building species of corals do not flourish in a greater depth of water than 20 fathoms, Darwin argued that all coral islands must have a rocky base, and that it was inconceivable that, in such large tracts of sea as occur in the Pacific and Indian oceans, there should be a vast number of submarine peaks or banks all rising to within 20 or 30 fathoms of the surface and none emerging above it. But on the supposition that the atolls and encircling reefs were formed round land which was undergoing a slow movement of subsidence, their structure could easily be explained. Take the case of an island consisting of a single high peak. At first the coral growth would form a fringing reef clinging to its shores. As the island slowly subsided into the ocean the upward growth of coral would keep the outer rim of the reef level with or within a few fathoms of the surface, so that, as subsidence proceeded, the distance between the outer rim of the reef and the sinking land would continually increase, with the result that a barrier-reef would be formed separated by a wide channel from the central peak. As corals and other organisms with calcareous skeletons live in the channel, their remains, as well as the accumulation of coral and other debris thrown over the outer edge of the reef, would maintain the channel at a shallower depth than that of the ocean outside. Finally, if the subsidence continued, the central peak would disappear beneath the surface, and an atoll would be left consisting of a raised margin of reef surrounding a central lagoon, and any pause during the movement of subsidence would result in the formation of raised islets or a strip of dry land along the margin of the reef. Darwin's theory was published in 1842, and found almost universal acceptance, both because of its simplicity and its applicability to every known type of coral-reef formation, including such difficult cases as the Great Chagos Bank, a huge submerged atoll in the Indian Ocean.

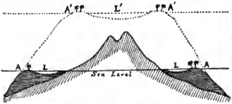


FIG. 20.—Diagram showing the formation of an atoll during subsidence. (After Darwin.) The lower part of the figure represents a barrier reef surrounding a central peak. A, A, Outer edges of the barrier reef at the sea-level; the cocoa-nut trees indicate dry land formed on the edges of the reef; L, L, lagoon channel; A′, A′, outer edges of the atoll formed by upgrowth of the coral during the subsidence of the peak; L′, lagoon of the atoll. The vertical scale is considerably exaggerated as compared with the horizontal scale.

Darwin's theory was adopted and strengthened by Dana, who had made extensive observations among the Pacific coral reefs between 1838 and 1842, but it was not long before it was attacked by other observers. In 1851 Louis Agassiz produced evidence to show that the reefs off the south coast of Florida were not formed during subsidence, and in 1863 Karl Semper showed that in the Pelew islands there is abundant evidence of recent upheaval in a region where both atolls and barrier-reefs exist. Latterly, many instances of recently upraised coral formations have been described by Wharton, Guppy, Gardiner, and others, and Alexander Agassiz and Murray have brought forward a mass of evidence tending to shake the subsidence theory to its foundations. Murray has pointed out that the deep-sea soundings of the *Tuscarora* and *Challenger* have proved the existence of a large number of submarine elevations rising out of a depth of 2000 fathoms or more to within a few hundred fathoms of the surface. The existence of such banks was unknown to Darwin, and removes his objections to Chamisso's theory. For although they may at first be too far below the surface for reef-building corals, they afford a habitat for numerous echinoderms, molluscs, crustacea, and deep-sea corals, whose skeletons accumulate on their summits, and they further receive a constant rain of the calcareous and silicious skeletons of minute organisms which teem in the waters above. By these agencies the banks are gradually raised to the lowest depth at which reef-building corals can flourish, and once these establish themselves they will grow more rapidly on the periphery of the bank, because they are more favourably situated as regards food-supply. Thus the reef will rise to the surface as an atoll, and the nearer it approaches the surface the more will the corals on the exterior faces be favoured, and the more will those in the centre of the reef decrease, for experiment has shown that the minute pelagic organisms on which corals feed are far less abundant in a lagoon than in the sea outside. Eventually, as the margin of the reef rises to the surface and material is accumulated upon it to form islets or continuous land, the coral growth in the lagoon will be feeble, and the solvent action of sea-water and the scour of the tide will tend to deepen the lagoon. Thus the considerable depth of some lagoons, amounting to 40 or 50 fathoms, may be accounted for. The observations of Guppy in the Solomon Islands have gone far to confirm Murray's conclusions, since he found in the islands of Ugi, Santa Anna, and Treasury and Stirling islands unmistakable evidences of a nucleus of volcanic rock, covered with soft earthy bedded deposits several hundred feet thick. These deposits are highly fossiliferous in parts, and contain the remains of pteropods, lamellibranchs, and echinoderms, imbedded in a foraminiferous deposit mixed with volcanic debris, like the deep-sea muds brought up by the *Challenger*. The flanks of these elevated beds are covered with coralline limestone rocks varying from 100 to 16 feet in thickness. One of the islands, Santa Anna, has the form of an upraised atoll, with a mass of coral limestone 80 feet in vertical thickness, resting on a friable and sparingly argillaceous rock resembling a deep-sea deposit. A. Agassiz, in a number of important researches on the Florida reefs, the Bahamas, the Bermudas, the Fiji Islands, and the Great Barrier-reef of Australia, has further shown that many of the peculiar features of these coral formations cannot be explained on the theory of subsidence, but are rather attributable to the natural growth of corals on banks formed by prevailing currents, or on extensive shore platforms or submarine flats formed by the erosion of pre-existing land surfaces.

In face of this accumulated evidence, it must be admitted that the subsidence theory of Darwin is inapplicable to a large number of coral reefs and islands, but it is hardly possible to assert, as Murray does, that no atolls or barrier-reefs have ever been developed after the manner indicated by Darwin. The most recent research on the structure of coral reefs has also been the most thorough and the most convincing. It is obvious that, if Murray's theory were correct, a bore hole sunk deep into an atoll would pass through some 100 feet of coral rock, then through a greater or less thickness of argillaceous rock, and finally would penetrate the volcanic rock on which the other materials were deposited. If Darwin's theory is correct, the boring would pass through a great thickness of coral rock, and finally, if it went deep enough, would pass into the original rock which subsided below the waters. An expedition sent out by the Royal Society of London started in 1896 for the island of Funafuti, a typical atoll of the Ellice group in the Pacific Ocean, with the purpose of making a deep boring to test this question. The first attempt was not successful, for at a depth of 105 feet the refractory nature of the rock stopped further progress. But a second attempt, under the management of Prof. Edgeworth David of Sydney, proved a complete success. With improved apparatus, the boring was carried down to a depth of 697 feet (116 fathoms), and a third attempt carried it down to 1114 feet (185 fathoms). The boring proves the existence of a mass of pure limestone of organic origin to the depth of 1114 feet, and there is no trace of any other rock. The organic remains found in the core brought up by the drill consist of corals, foraminifera, calcareous algæ, and other organisms. The results of the examination of the core had not been published at the time this article was written, but, by the courtesy of Professor Judd, the writer has been able to examine the core and satisfy himself as to the truth of the above statements. A boring was also made from the deck of a ship into the floor of the lagoon, which shows that under 100 feet of water there exists at the bottom of the lagoon a deposit more than 100 feet thick, consisting of the remains of a calcareous alga, *Halimeda opuntia*, mixed with abundant foraminifera. At greater depths, down to 245 feet, the same materials, mixed with the remains of branching madrepores, were met with, and further progress was stopped by the existence of solid masses of coral, fragments of porites, madrepora, and heliopora having been brought up in the core. These are shallow-water corals, and their existence at a depth of nearly 46 fathoms buried beneath a mass of halimeda and foraminifera, is clear evidence of recent subsidence. Halimeda grows abundantly over the floor of the lagoon of Funafuti, and has been observed in many other lagoons. The writer collected a quantity of it in the lagoon of Diego Garcia in the Chagos group. The boring demonstrates that the lagoon of Funafuti has been filled up to an extent of at least 245 feet (nearly 41 fathoms), and this fact accords well with Darwin's theory, but is incompatible with that of Murray. In the present state of our knowledge it seems reasonable to conclude that coral reefs are formed wherever the conditions suitable for growth exist, whether in areas of subsidence, elevation, or rest. A considerable number of reefs, at all events, have not been formed in areas of subsidence, and of these the Florida reefs, the Bermudas, the Solomon islands, and possibly the great barrier-reef of Australia are examples. Funafuti would appear to have been formed in an area of subsidence, and it is quite probable that the large groups of low-lying islands in the Pacific and Indian oceans have been formed under the same conditions. At the same time, it must be remembered that the atoll or barrier-reef shape is not necessarily evidence of formation during subsidence, for the observations of Semper, A. Agassiz, and Guppy are sufficient to prove that these forms of reefs may be produced by the natural growth of coral, modified by the action of waves and currents in regions in which subsidence has certainly not taken place.

AUTHORITIES.—The following list contains only the names of the more important and more general works on the structure and classification of corals and on coral reefs. For a fuller bibliography the works marked with an asterisk should be consulted :—1. *A. ANDRES. *Fauna und Flora des Golfes von Neapel*, ix. 1884.— 2. H. M. BERNARD. "Catalogue of Madreporarian Corals" in Brit. Museum, ii. 1896, iii. 1897.—3. *G. C. BOURNE. "Anthozoa," in Lankester's *Treatise on Zoology*, vol. ii. 1900. London, A. and C. Black.—4. G. BROOK. "*Challenger* Reports," *Zoology*, xxxii. 1899. (*Antipatharia.*)—5. "Cat. Madrep. Corals," Brit. Mus. i. 1893.—6. D. C. DANIELSSEN. "Report Norwegian North Atlantic Exploring Expedition," *Zoology*, xix. 1890.—7. P. M. DUNCAN. *Journ. Linnean Soc.* xviii. 1885.— 8. P. H. GOSSE. *Actinologia britannica.* London, 1860.—9. O. and R. HERTWIG. *Die Actinien.* Jena, 1879.—10. R. HERTWIG. "*Challenger* Reports," *Zool.* vi. 1882, and xxvi. 1888.—11. *C. B. KLUNZINGER. *Die Korallthiere des Rothes Meeres.* Berlin, 1877.—12. *G. VON KOCH. *Fauna und Flora des Golfes von Neapel*, xv. 1887. 13. *Mitth. Zool. Stat. Neapel*, ii. 1882, and xii. 1897. 14. *Palæontographica*, xxix. 1883. (Also many papers in the *Morphol. Jahrbuch* from 1876 to 1898.)—15. F. KOBY. "Polypiers Jurassiques de la Suisse," *Mem. Soc. Palæont. Suisse*, vii.-xvi. 1880-1889.—16. A. VON KÖLLIKER. "Die Pennatuliden," *Abh. d. Senck. Naturf. Gesell.* vii.—17. *"*Challenger* Reports," *Zoology*, i. *Pennatulidæ*. 1880.—18. KOREN and DANIELSSEN. *Norske Nordhavs Exped. Alcyonida.* 1887.—19. H. DE LACAZE-DUTHIERS. *Hist. Nat. du Corail.* Paris, 1864.— 20. H. MILNE-EDWARDS and J. HAIME. *Hist. Nat. des Coralliaires.* Paris, 1857.—21. H. N. MOSELEY. "*Challenger* Reports," *Zool.* ii. 1881.—22. H. A. NICHOLSON. *Palæozoic Tabulate Corals.* Edinburgh, 1879.—23. M. M. OGILVIE. *Phil. Transactions*, clxxxvii. 1896.—24. E. PRATZ. *Palæontographica*, xxix. 1882.—25. J. J. QUELCH. "*Challenger* Reports," *Zool.* xvi. 1886.—26. *P. S. WRIGHT and TH. STUDER. "*Challenger* Reports," *Zool.* xxxi. 1889. **Coral Reefs and Islands**:— 27. A. AGASSIZ. Many publications in the *Mem. Amer. Acad.* 1883, and *Bull. Mus. Comp. Zool.* Harvard, 1889-1899.—28. J. D. DANA. *Corals and Coral Islands.* London and New York, 1885.—29. *C. DARWIN. *The Structure and Distribution of Coral Reefs*, 3rd edit. 1889.—30. H. B. GUPPY. "The Recent Calcareous Formations of the Solomon Group," *Trans. Roy. Soc. Edinb.* xxxii. 1885.—31. *R. LANGENBECK. "Die neueren Forschungen über die Korallenriffe," *Hettner Geogr. Zeitsch.* iii. 1897. 32. J. MURRAY. "On the Structure and Origin of Coral Reefs and Islands," *Proc. Roy. Soc. Edinb.* x. 1879-80.—33. J. MURRAY and IRVINE. "On Coral Reefs and other Carbonate of Lime Formations in Modern Seas," *Proc. Roy. Soc. Edinb.* 1889. —34. W. SAVILE KENT. *The Great Barrier Reef of Australia.* London, W. H. Allen and Co., 1893.—35. C. SEMPER. *Animal Life. Internat. Sci. Series*, vol. xxxi. 1881. (G. C. B.)

Anthrax. See EXPERIMENTS ON ANIMALS.

Anthropology.—The following additional observations, supplementing the article ANTHROPOLOGY in *Ency. Brit.*, 9th ed., vol. ii., are placed under headings corresponding to those previously adopted.

Man's Place in Nature.—In the original article use is made of the exposition of the theory of human development, as viewed on its physical side, by Professor Huxley (see his *Man's Place in Nature*, 1863; reprinted in Collected Essays, vol. vii.). Huxley's argument has, on the whole, stood its ground, and a reproduction of his series of skeletons is given in our Plate (Fig. 2) as serving better than a detailed anatomical statement. Its significance in the problem of human descent requires some explanation. The acknowledgment of man's structural similarity with the anthropomorphous species nearest approaching him was made by Linnæus, who, in his

Systema Naturæ (1735) grouped them together as the highest order of Mammalia, to which he gave the name of Primates. The *Amœnitates Academicæ* (vol. vi., Leyden, 1764), published under the auspices of Linnæus, contains a remarkable picture which illustrates a discourse by his disciple Hoppius, and is here reproduced in the Plate, Fig. 1. In this picture, which shows the crudeness of the zoological notions current in the 18th century both as to men and apes, there are set in a row four figures: (*a*) a recognizable orang-utan, sitting and holding a staff; (*b*) a chimpanzee, absurdly humanized as to head, hands, and feet; (*c*) a hairy woman, with a tail a foot long; (*d*) another woman, more completely coated with hair. The great Swedish naturalist was possibly justified in treating the two latter creatures as quasi-human, for they seem to be grotesque exaggerations of such tailed and hairy human beings as really, though rarely, occur, and are apt to be exhibited as monstrosities (see Bastian and Hartmann, *Zeitschrift für Ethnologie*, Index, "Geschwänzte Menschen"; Gould and Pile, *Anomalies and Curiosities of Medicine*, 1897). To Linnæus, however, they represented normal anthropomorpha or man-like creatures, vouched for by visitors to remote parts of the world. This opinion of the Swedish naturalist seems to have been little noticed in Great Britain till it was taken up by the learned but credulous Scots judge, Lord Monboddo (see his *Origin and Progress of Language*, 1774, &c.; *Antient Metaphysics*, 1778). He had not heard of the tailed men till he met with them in the work of Linnæus, with whom he entered into correspondence, with the result that he enlarged his range of mankind with races of sub-human type. One was founded on the description by the Swedish sailor Niklas Köping of the ferocious men with long tails inhabiting the Nicobar Islands. Another comprised the orang-utans of Sumatra, who were said to take men captive and set them to work as slaves. One of these apes, it was related, served as a sailor on board a Jamaica ship, and used to wait on the captain. These are stories which seem to carry their own explanation. When the Nicobar Islands were taken over by the British Government two centuries later, the native warriors were still wearing their peculiar loin-cloth hanging behind in a most tail-like manner (E. H. Man, *Journal Anthropological Institute*, vol. xv. p. 442). As for the story of the orang-utan cabin boy, this may even be verbally true, it being borne in mind that in the Malay languages the term *orang-utan*, "man of the forest," was originally used for inland forest natives and other rude men, rather than for the *miyas* apes to which it has come to be generally applied by Europeans. The speculations as to primitive man connected with these stories diverted the British public, headed by Dr Johnson, who said that Monboddo was "as jealous of his tail as a squirrel." Linnæus's primarily zoological classification of man did not, however, suit the philosophical opinion of the time, which responded more readily to the systems represented by Buffon, and later by Cuvier, in which the human mind and soul formed an impassable wall of partition between him and other mammalia, so that the definition of man's position in the animal world was treated as not belonging to zoology, but to metaphysics and theology. It has to be borne in mind that Linnæus, plainly as he recognized the likeness of the higher simian and the human types, does not seem to have entertained the thought of accounting for this similarity by common descent. It satisfied his mind to consider it as belonging to the system of nature, as indeed remained the case with a greater anatomist of the following century, Richard Owen. The present drawing, which under the authority of Linnæus shows an anthropomorphic series from which the normal type of man, the *homo sapiens*, is conspicuously absent, brings zoological similarity into view without suggesting kinship to account for it. There are few ideas more ingrained in ancient and low civilization than that of relationship by descent between the lower animals and man. Savage and barbaric religions recognize it, and the mythology of the world has hardly a more universal theme. But in educated Europe such ideas had long been superseded by the influence of theology and philosophy, with which they seemed too incompatible. In the 19th century, however, Lamarck's theory of the development of new species by habit and circumstance led through Wallace and Darwin to the doctrines of the hereditary transmission of acquired characters, the survival of the fittest, and natural selection. Thenceforward it was impossible to exclude a theory of descent of man from ancestral beings whom zoological similarity connects also, though by lines of descent not at all clearly defined, with ancestors of the anthropomorphic apes. In one form or another such a theory of human descent has in our time become part of an accepted framework of zoology, if not as a demonstrable truth, at any rate as a working hypothesis which has no effective rival.

The new development from Linnæus's zoological scheme which has thus ensued appears in Huxley's diagram of simian and human skeletons (Fig. 2, (*a*) gibbon; (*b*) orang; (*c*) chimpanzee; (*d*) gorilla; (*e*) man). Evidently suggested by the Linnean picture, this is brought up to the modern level of zoology, and continued on to man, forming an introduction to his zoological history hardly to be surpassed. Some of the main points it illustrates may be briefly stated here, the reader being referred for further information to Huxley's *Essays*. In tracing the osteological characters of apes and man through this series, the general system of the skeletons, and the close correspondence in number and arrangement of vertebræ and ribs, as well as in the teeth, go far towards justifying the opinion of hereditary connexion. At the same time, the comparison brings into view differences in human structure adapted to man's pre-eminent mode of life, though hardly to be accounted its chief causes. It may be seen how the arrangement of limbs suited for going on all-fours belongs rather to the apes than to man, and walking on the soles of the feet rather to man than the apes. The two modes of progression overlap in human life, but the child's tendency when learning is to rest on the soles of the feet and the palms of the hands, unlike the apes, which support themselves on the sides of the feet and the bent knuckles of the hands. With regard to climbing, the long stretch of arm and the grasp with both hands and feet contribute to the arboreal life of the apes, contrasting with what seem the mere remains of the climbing habit to be found even among forest savages. On the whole, man's locomotive limbs are not so much specialized to particular purposes, as generalized into adaptation to many ends. As to the mechanical conditions of the human body, the upright posture has always been recognized as the chief. To it contributes the balance of the skull on the cervical vertebræ, while the human form of the pelvis provides the necessary support to the intestines in the standing attitude. The marked curvature of the vertebral column, by breaking the shock to the neck and head in running and leaping, likewise favours the erect position. The lowest coccygeal vertebræ of man remain as a rudimentary tail. While it is evident that high importance must be attached to the adaptation of the human body to the life of diversified intelligence and occupation he has to lead, this must not be treated as though it were the principal element of the superiority of man, whose comparison with all lower genera of mammals must be mainly directed to the intellectual organ, the brain. Comparison of the brains of vertebrate animals brings into view the immense difference between the small, smooth brain of a fish or bird and the large and convoluted organ in man. In man, both size and complexity contribute to the increased area of the cortex or outer layer of the brain, which within the last few years has been fully ascertained to be the seat of the mysterious processes by which sensation furnishes the groundwork of thought. Schäfer (*Textbook of Physiology*, vol. ii. p. 697) thus defines it: "The cerebral cortex is the seat of the intellectual functions, of intelligent sensation or consciousness, of ideation, of volition, and of memory." Not to enter into the difficult details of comparison of the extent of this thinking layer in the higher apes and man, it may suffice to compare the absolute quantity of brain in the gorilla and average man, which has been estimated as 1 to 2. So evident is the preponderance, that it is plainly seen in the present series of skeletons which have already served so many purposes, and where the outside of the brainpan in each gives a rough measure of the brain contained within.

The wide acceptance of the Darwinian theory, as applied to the descent of man, has naturally roused anticipation that geological research, which provides evidence of the animal life of incalculably greater antiquity, would furnish fossil remains of some comparatively recent being intermediate between the anthropomorphic and the anthropic types. This expectation has hardly been fulfilled, but of late years the notion of a variety of the human race, geologically ancient, differing from any known in historic times, and with characters approaching the simian, has been supported by further discoveries. To bring this to the reader's notice, top and side views of three skulls, as placed together in the human development series in the Oxford University Museum, are represented in the Plate, for the purpose of showing the great size of the orbital ridges, which the reader may contrast with his own by a touch with his fingers on his forehead. The first (Fig. 3) is the famous Neanderthal skull from near Düsseldorf, described by Schaafhausen in Muller's *Archiv*, 1858; Huxley in Lyell, *Antiquity of Man*, p. 86, and in *Man's Place in Nature*. The second (Fig. 4) is the skull from the cavern of Spy in Belgium (De Puydt and Lohest, *Compte Rendu du Congrès de Namur*, 1886). The foreheads of these two skulls have an ape like form, obvious on comparison with the simian skulls of the gorilla and other apes, and visible even in the small-scale figures in the Plate, Fig. 2. Among modern tribes of mankind the forehead of the Australian aborigines makes the nearest approach to this type, as was pointed out by Huxley. This brief description will serve to show the importance of a later discovery. At Trinil, in Java, in an equatorial region where, if anywhere, a being intermediate between the higher apes and man would seem likely to be found, Dr Dubois in 1891-92 excavated from a bed, considered by him to be of Sivalik formation (Pliocene), a thighbone which competent anatomists decide to be human, and a remarkably depressed calvaria or skull-cap (Fig. 5), bearing a certain resemblance in its proportions to the corresponding part of the simian skull. These remains were referred by their discoverer to an animal intermediate between man and ape, to which he gave the name of *Pithecanthropus erectus*, but the interesting discussions on the subject showed divergence of opinion among leading anatomists. At any rate, classing the Trinil skull as human, it may be described as tending towards the simian type more than any other known (Eug. Dubois, *Pithecanthropus erectus*, Batavia, 1894; *Trans. of Royal Dublin Soc.* vol. vi. 1898; *Journal Anthropological Institute*, vol. xxv. p. 240; *Nature*, vol. li. 1895).

Development of Civilization.—In recent years no such fundamental alteration has taken place in scientific views as to man's age on the earth, as had been brought about previously by the extension of his antiquity back from history into geology. It was an immense change in current opinion to substitute for a chronology of centuries a vague computation of hundreds of thousands of years. The new views, however, met with comparatively little opposition, partly because the way had been already broken by geology assigning to the strata of the earth an incalculable antiquity, and still more because the extension of the human period was no merely speculative doctrine, but rested on visible fact. It was an object-lesson on the largest scale to look across a valley like that of the Thames, and to imagine the vast time required for its excavation by the waters since the river drift-gravels were left high on the slopes, containing rude stone implements lying with the bones of the mammoth and rhinoceros, which plainly showed man to have been their contemporary. These stone implements in the Quaternary drift-gravels, and other relics of human art in the cave deposits, while furnishing the main proof of man's high antiquity, contain also evidence of his then state of culture. His drawings on bone or tusk found in the caves show no mean artistic power, as appears by the three specimens copied in the Plate. That representing two deer (Fig. 6) was found so early as 1852 in the breccia of a limestone cave on the Charente, and its importance recognized in a remarkable letter by Prosper Merimée, as at once historically ancient and geologically modern (*Congrès d'Anthropologie et d'Archéologie Préhistoriques*, Copenhagen, 1869, p. 128). The other two are the famous mammoth from the cave of La Madelaine, on which the woolly mane and huge tusks of *Elephas primigenius* are boldly drawn (Fig. 7); and the group of man and horses (Fig. 8). There has been found one other contemporary portrait of man, where a hunter is shewn stalking an aurochs.

That the men of the Quaternary period knew the savage art of producing fire by friction, and roasted the flesh on which they mainly subsisted, is proved by the fragments of charcoal found in the cave deposits, where also occur bone awls and needles, which indicate the wearing of skin clothing, like that of the modern Australians and Fuegians. Their bone lance-heads and dart-points were comparable to those of northern and southern savages. Particular attention has to be given to the stone implements used by these earliest known of mankind. The division of tribes in the stone implement stage into two classes, according to their proficiency in this most important art, furnishes in some respects the best means of determining their rank in general culture. In order to put this argument clearly before the reader, a few selected implements are figured in the Plate. The group in Fig. 9 contains tools and weapons of the Neolithic or New Stone Age, such as are dug up on European soil; they are evident relics of ancient populations who used them till replaced by metal. The stone hatchets are symmetrically shaped and edged by grinding, while the cutting flakes, scrapers, spear and arrow heads, are of high finish. Direct knowledge of the tribes who made them is scanty, but implements so similar in make and design having been in use in North and South America until modern times, it may be assumed for purposes of classification that the Neolithic peoples of the New World were at a similar barbarous level in industrial arts, social organization, moral and religious ideas. Such comparison, though needing caution and reserve, at once proved of great value to anthropology. When, however, there came to light from the drift-gravels and limestone caves of Europe the Palæolithic implements, of which some types are shown in the group (Fig.

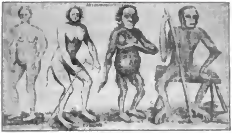


Fig. 1.

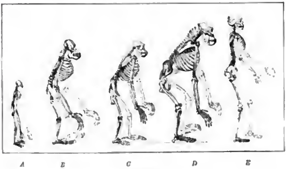


Fig. 2.

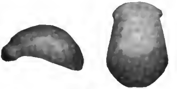


Fig. 3.

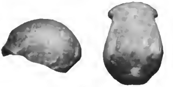


Fig. 4.

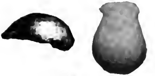


Fig. 5.

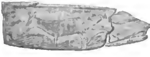


Fig. 6.

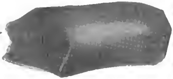


Fig. 7.

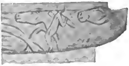


Fig. 8.

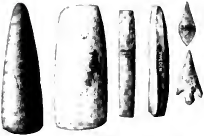


Fig. 9.

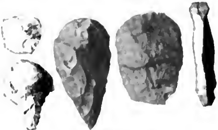


Fig. 10.

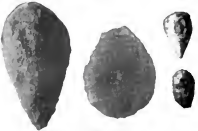


Fig. 11.

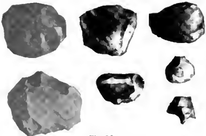


Fig. 12.

ANTHROPOLOGY (see pp. 464-467).

10), the difficult problem presented itself what degree of general culture these rude implements belonged to. On mere inspection, their rudeness, their unsuitability for being hafted, and the absence of shaping and edging by the grindstone, mark their inferiority to the Neolithic implements. Their immensely greater antiquity was proved by their geological position and their association with a long extinct fauna, and they were not, like the Neoliths, recognizable as corresponding closely to the implements used by modern tribes. There was at first a tendency to consider the Palæoliths as the work of men ruder than savages, if, indeed, their makers were to be accounted human at all. Since then, however, the problem has passed into a more manageable state. Stone implements, more or less approaching the European Palæolithic type, were found in Africa from Egypt southwards, where in such parts as Somaliland and Cape Colony they lie about on the ground, as though they had been the rough tools and weapons of the rude inhabitants of the land at no very distant period. The group in Fig. 11 in the Plate shows the usual Somaliland types. These facts tended to remove the mystery from Palæolithic man, though too little is known of the ruder ancient tribes of Africa to furnish a definition of the state of culture which might have co-existed with the use of Palæolithic implements. Information to this purpose, however, can now be furnished from a more outlying region. This is Tasmania, where, as in the adjacent continent of Australia, the survival of marsupial animals indicates long isolation from the rest of the world. Here, till far on into the 19th century, the Englishmen could watch the natives striking off flakes of stone, trimming them to convenient shape for grasping them in the hand, and edging them by taking off successive chips on one face only. The group in Fig. 12 shows ordinary Tasmanian forms, two of them being finer tools for scraping and grooving. (For further details reference may be made to H. Ling Roth, *The Tasmanians*, 2nd ed. 1899; R. Brough Smyth, *Aborigines of Victoria*, 1878, vol. ii.; *Papers and Proceedings of Royal Society of Tasmania*; and papers by the present writer in *Journal of the Anthropological Institute*.) The Tasmanians, when they came in contact with the European explorers and settlers, were not the broken outcasts they afterwards became. They were a savage people, perhaps the lowest in culture of any known, but leading a normal, self-supporting, and not unhappy life, which had probably changed little during untold ages. The accounts, imperfect as they are, which have been preserved of their arts, beliefs, and habits, thus present a picture of the arts, beliefs, and habits of tribes whose place in the Stone Age was a grade lower than that of Palæolithic man of the Quaternary period.

The Tasmanian stone implements, figured in the Plate, show their own use when it is noticed that the rude chipping forms a good hand-grip above, and an effective edge for chopping, sawing, and cutting below. But the absence of the long-shaped implements, so characteristic of the Neolithic and Palæolithic series, and serviceable as picks, hatchets, and chisels, shows remarkable limitation in the mind of these savages, who made a broad, hand-grasped knife their tool of all work to cut, saw, and chop with. Their weapons were the wooden club or waddy notched to the grasp, and spears of sticks, often crooked but well balanced, with points sharpened by tool or fire, and sometimes jagged. No spear-thrower or bow and arrow was known. The Tasmanian savages were crafty warriors and kangaroo-hunters, and the women climbed the highest trees by notching, in quest of opossums. Shell-fish and crabs were taken, and seals knocked on the head with clubs, but neither fish-hook nor fishing-net was known, and indeed swimming fish were avoided as food. Meat and vegetable food, such as fern-root, was broiled over the fire, but boiling in a vessel was unknown. The fire was produced by the ordinary savage fire-drill. Ignorant of agriculture, with no dwellings but rough huts or breakwinds of sticks and bark, without dogs or other domestic animals, these savages, until the coming of civilized man, roamed after food within their tribal bounds. Logs and clumsy floats of bark and grass enabled them to cross water under favourable circumstances. They had clothing of skins rudely stitched together with bark thread, and they were decorated with simple necklaces of kangaroo teeth, shells, and berries. Among their simple arts, plaiting and basket-work was one in which they approached the civilized level. The pictorial art of the Tasmanians was poor and childish, quite below that of the Palæolithic men of Europe. The Tasmanians spoke a fairly copious agglutinating language, well marked as to parts of speech, syntax, and inflexion. Numeration was at a low level, based on counting fingers on one hand only, so that the word for man (*puggana*) stood also for the number 5. The religion of the Tasmanians, when cleared from ideas apparently learnt from the whites, was a simple form of animism based on the shadow (*warrawa*) being the soul or spirit. The strongest belief of the natives was in the power of the ghosts of the dead, so that they carried the bones of relatives to secure themselves from harm, and they fancied the forest swarming with malignant demons. They placed weapons near the grave for the dead friend's soul to use, and drove out disease from the sick with the intruding ghost which had caused it. Of greater special spirits of Nature we find something vaguely mentioned. The earliest recorders of the native social life set down such features as their previous experience of rude civilized life had made them judges of. They notice the self-denying affection of the mothers, and the hard treatment of the wives by the husbands, polygamy, and the shifting marriage unions. But when we meet with a casual remark as to the tendency of the Tasmanians to take wives from other tribes than their own, it seems likely that they had some custom of exogamy which the foreigners did not understand. Meagre as is the information preserved of the arts, thoughts, and customs of these survivors from the lower Stone Age, it is of value as furnishing even a temporary and tentative means of working out the development of culture on a basis not of conjecture but of fact. (E. B. T.)

Anthropometry is a system of identifying and classifying individuals by measurement, invented for police purposes about 1880 by M. Bertillon of the *Service de la Sûreté* or criminal department of the prefecture of police in Paris, and since adopted in some form by nearly every civilized government. The system rests upon two assumptions, which may be taken to have been proved. The first is that the dimensions of certain bones and bony structures remain practically constant in the individual throughout adult life; and the second is that such dimensions vary so much in different persons that if several bones be measured very few individuals will be found to have all the measurements absolutely the same. Taken together, these facts provide the basis for an exact method of identifying at any future time a person who has once been measured, and of distinguishing between that person and others. Such a method might obviously be useful in any situation in which it is desirable to establish identity or prevent personation, but its most important application is in dealing with crime, and especially with "recidivists" or old offenders who have been previously convicted, and who endeavour to escape recognition by giving false accounts of themselves, and by every other means in their power. In the case of small communities and local crime personal identification is usually a simple matter and presents little difficulty to the police, who are more or less familiar with all the persons with whom they are called upon to deal; but it becomes difficult or impossible with persons who travel from place to place, as the more important professional criminals do, and in great cities by sheer excess of numbers. Previously to the introduction of the Bertillon system the means relied upon were (1) the memory of warders and policemen, who often had to travel to distant places to view prisoners, (2) photographs, (3) written descriptions, with special reference to marks or other peculiarities. These things have their uses still, but by themselves they formed a very imperfect means of identification. The chief defects in practice were (1) frequent failure to identify, (2) liability to mis-identification—not very common but of the greatest importance to the innocent, (3) time, labour, and expense involved in searching records and circulating descriptions.

Anthropometry was designed to overcome all these defects. The great advantage claimed for it lies in the systematic recording on a uniform plan of the distinctive features of each criminal, and the classification of these records on the numerical basis afforded by measurement. The principle of classification may be explained as follows:—Five dimensions are taken as a basis, namely (1) length of head, (2) breadth of head, (3) length of left middle finger, (4) length of left foot, (5) length of left forearm. These were chosen by M. Bertillon chiefly on the ground that they are the most constant in the individual and the easiest to take accurately; but they may be varied without affecting the principle. Each of these is then divided into three classes:—(1) long, (2) medium, (3) short. Thus heads upwards of 191 millimetres in length are classed "long," those of 185 to 190 millimetres are "medium," and those of less than 185 are "short." Similarly with the breadth of head, length of middle finger, and so on. This division of the five dimensions into three classes each gives 3^5 or 243 classes, which are assumed to be approximately equal. Supposing, now, it is required to keep a register of 90,000 criminals, as contemplated by M. Bertillon, each represented by a card containing personal details, photograph, and other particulars. The first division by length of head will divide the 90,000 cards into three sections of 30,000 each; these are subdivided by breadth of head into nine subsections of 10,000 each, and again by the remaining measurements successively into 27 sets of 3300 each, 81 of 1100 each, and 243 of 370 each. The cards are kept in a cabinet, which is divided into sections and subsections corresponding to the measurements described, and eventually into drawers, representing the last subdivision. There are, therefore, 243 drawers, each containing about 370 cards. Then a further subdivision of the cards in each drawer is given by the height, the length of the little finger, and lastly by the colour of the eye. The height gives three subdivisions of 124 each, which are further divided into groups of 41 by the little finger, and finally into packets of 6 by the colour of the eye, of which seven varieties are distinguished. The practical working of the system can be readily understood. A prisoner is brought into the Prefecture; the police require to know his record, and whether previously convicted or not. He gives a name which is not found in the alphabetical register, kept in addition to the anthropometric register. Let us suppose that the name is false, and that he is really an old offender. In order to find out it is necessary to search the records. It is here that the anthropometric classification comes in. Instead of searching through photographic albums and voluminous records, at the cost of much time and labour, and with a doubtful result, the authorities can, theoretically at least, lay their hands with certainty on the document required within a few minutes even among 90,000 others. The man is measured, and his head-length is found to be over 191 millimetres. He therefore falls under the "longs," and two-thirds of the registration cabinet, or 60,000 records, are at once eliminated. The head-breadth in like manner eliminates 20,000 more; and so on until the search comes down to a bundle of six or so, among which the suspect's card is found, with photograph, description, &c. The whole thing is entirely independent of names. The actual identification is made by means of the photograph and distinctive marks, if any. Some additional measurements, including the dimensions of the ear, are taken by M. Bertillon, but they are not essential. The system is still undergoing modification and improvement by the introduction of new features. An important addition is the finger-print process, described below.

The weak point in the system is the margin which has to be allowed for error in the measurements. M. Bertillon himself allows 1 millimetre, but with less skilful or less careful officers than those at the Paris Prefecture it may be necessary to allow more. This introduces a doubt into the classification, rendering it uncertain to which of two sections measurements near the dividing line really belong, and so increasing the area of search to a corresponding degree. In practice, however, the system has proved highly successful in France. A striking result is the great diminution in the number of habitual criminals who attempt to evade recognition; the inference is that they have learnt to regard the endeavour as futile.

In 1893 a departmental committee was appointed by the British Home Office to inquire into the anthropometric system and also into finger-prints. It reported in the following year, recommending the adoption of anthropometric classification by means of the five primary measurements described above; but for the further classification and actual identification it recommended the finger-print system elaborated by Mr Francis Galton in preference to the Bertillon secondary measurements, as being more scientific and more accurate. These recommendations were provisionally adopted with some modifications, and have been in use in England ever since. The actual measurements now taken are the following:—(1) head length, (2) head breadth, (3) face breadth, (4) left middle finger, (5) left cubit, (6) left foot, (7) height. These are entered on a form together with other details, including age, name, complexion, hair, eyes, and distinctive marks. The prisoner's photograph is also affixed in a space left vacant for the purpose. The reverse side of the same piece of paper is devoted to the finger-prints. Impressions of the thumb and four fingers of each hand are taken, both with the fingers together and each in a separate space. The papers are classified and arranged in sections to form a register in the manner already explained. It is to be noted, however, that owing to difference of judicial procedure the system is carried out in a somewhat different way in Great Britain, and is used to a much less extent than in France. The French law permits the arrest, detention, and interrogation of persons on mere suspicion, and the identification of "recidivists" at this stage is of great importance, because it places a powerful weapon in the hands of the police and of the examining magistrate in working up the case. It is also important for the protection of the innocent. All persons arrested are therefore measured at once by the police as a matter of routine, and this is done by specially trained and skilled officers at the identification bureau. The

English law only permits it to be done to persons committed for trial or under remand at the formal request of a chief constable. The measurements, therefore, are not taken by the police, but by prison officials, and the system is only applied to a comparatively small number of criminals. It is carried out, however, under the supervision of a central office attached to the metropolitan police, where the register is kept. Some 200 officers in the different gaols throughout the United Kingdom have been instructed in Anthropometry. In Glasgow it is used by the police.

Finger Prints.—In 1823 Purkenje, the eminent physiologist of Breslau, drew attention to the subject of finger impressions. He distinguished nine types, and suggested a system of classification, but it was not followed up. The first practical application of the method was made by Sir William Herschel, of the Indian Civil Service, who introduced it into the district of Hooghly, in Bengal, as a means of identification, to meet the practice of personation prevalent in all the courts. He wrote a report recommending its general adoption in India, but his advice was not followed, and the practice lapsed in the Hooghly district after his departure. The subject was afterwards taken up as an anthropological study by Mr Francis Galton, and very fully worked out. It is thus explained in brief by Mr G. R. Henry, inspector-general of police, Lower Provinces:—

> The palmar surface of the hand and the sole of the foot are traversed by innumerable ridges, forming many varieties of pattern, and by creases. The ridge patterns and the ridge *characteristics* persist throughout the whole period of human life, and are so distinctive as to differentiate each individual from all others. An accurate reproduction of these ridges is obtained by inking the finger bulb and pressing it on paper, the impression thus recorded being a reversal of the pattern on the finger. All impressions may be arranged under one of four types, namely, arches, loops, whorls, composites. Arches subdivide into arches and tented arches; clear definitions demarcate arches from tented arches, and both from loops. Loops may be *ulnar* or *radial*, and are further differentiated from each other by ridge *counting* and by their ridge *characteristics*. Whorls are single- or double-cored; impressions of this type differ conspicuously from each other, owing to the innumerable varieties of pattern they present, but further demarcation is provided by ridge *tracing*. Composites include central pockets, lateral pockets, twinned loops, accidentals.

From this it will be seen that the classification is somewhat complicated and technical. For further explanation and for the practical application of the method the reader is referred to Mr Henry's book on *Finger Prints* (1900).

In 1892 Anthropometry was introduced into Bengal, and then into other provinces; but after some years' experience certain defects in working became apparent, and attention was turned to the alternative use of finger-prints, on which the Home Office, as previously mentioned, had reported favourably in 1894. Experiments in identification by finger-prints only were made in Bengal, and were so successful that in 1897 the government of India appointed a committee to examine both systems. It recommended the adoption of finger-prints on the Bengal plan "as being superior to the anthropometric method—(1) in simplicity of working; (2) in the cost of apparatus; (3) in the fact that all skilled work is transferred to a central or classification office; (4) in the rapidity with which the process can be worked; and (5) in the certainty of the results." Various theoretical objections to finger-prints have been raised, but they have no particular value. Obliteration of the ridges by injury is possible, but it would in itself be suspicious, and would constitute a most distinctive personal mark; obscuration by manual labour is not found to be a serious drawback. In June 1897 a resolution of the governor-general in council directed the adoption of the finger-print system throughout India, and its gradual substitution for the previously existing anthropometric system has since been carried out. Its use is not confined to the police department, but extends to all branches of public business.

It is probable that different systems may suit different conditions. Foreign governments now use for police purposes combinations of Anthropometry and finger-prints similar to that adopted in England. There are minor differences, but the systems are sufficiently alike to be available for dealing with international crime. The full advantage of scientific identification, however, will not be reaped until judicial procedure recognizes more clearly the distinction between professional and accidental criminals. On this point the committee of 1894 remarked:—"As there are some criminals who ought never to be sent to prison, there are others who ought never to be released; and when this distinction is established and provided for by legislation, it will be of even greater importance than at present to have an exact record of each criminal's offences."

Literature.—Bertillon.—*Instructions Signalétiques.* Henry.—*Classification and Uses of Finger Prints.* Spearman.—*Fortnightly Review*, March 1890; *New Review*, July 1893. Blue Book.—"Report on best Means available for identifying Habitual Criminals," 1894.

(A. Sl.)

Antibes, a small seaport of France, department of Alpes Maritimes, in the arrondissement of Grasse, 11 miles in direct line S.S.W. of Nice, on the railway from Toulon to Nice. The ramparts are being demolished. A state horticultural college was established in 1891. Industries include perfume'distilling. Population (1881), 3810; (1891), 4926; (1896), 4956; (1901), 6600.

Anticosti, a barren island of Quebec, Canada, situated in the northern portion of the Gulf of St Lawrence. It has been converted into an immense preserve for game of all kinds.

Antigo, a city of Wisconsin, U.S.A., the capital of Langlade county, situated in the north-eastern part of the state, on a branch of the Chicago and North-Western railway, at an altitude of 1483 feet. Its industries consist mainly in the manufacture of lumber. Population (1885), 1979; (1895), 5002; (1900), 5145.

Antigua, an island of the British West Indies, the largest member of the outer coralline chain, east of Nevis and north of Montserrat, with an area of 108 square miles. In 1881 the population was 34,000, and in 1891, 36,200, St. John, the capital, containing 7938. It forms, with Barbuda and Redonda, one of the five presidencies into which the Leeward group is divided, and is the seat of the general governing body. The local legislative council ceased to send four unofficial members to the Federal Legislative Council in 1898, when the legislature, in consideration of pecuniary assistance from the British Government, passed an act abrogating the semi-elective constitution which had existed since 1866. The island is now, like the other presidencies of the Leeward Islands colony, administered as a Crown Colony, and the legislative council consists of eight official and eight non-official members, all nominated by the governor. Education is by law compulsory, and there are many elementary schools throughout the island. There is a grammar school for boys and one for girls, and the Cambridge local examinations are held annually, as are the examinations of the University of London. Agricultural training is given under the Government at Skerrett's school. The Mico training institution was closed in 1899, and students are now trained in the Mico training college in Jamaica. The Anglican, Wesleyan, and Moravian churches are the most numerous. There is a small volunteer defence force. The island has direct steam communication with Great Britain, New York, and Canada, and is connected with the West India and Panama Telegraph Company's cable. The decline of the sugar industry has had a serious effect on the prosperity and public finances of the island; and, as in many other West Indian colonies, considerable retrenchments in public expenditure had to be effected during the last few years of the century, which were also marked by hurricane and drought. Sweet potatoes, yams, maize, and guinea-corn are grown for home consumption, and pine-apples are exported to a small extent. The lands were in 1899 classified as follows:—Cultivated in sugar-cane, 14,860 acres; other crops, 1660 acres; pasture, 22,350; uncultivated, 19,910; mountain and waste land, 10,495; total (estimated) 69,275 acres. In 1896 the exports, chiefly cane-sugar and pine-apples, were £131,000; in 1898, £79,000; and in 1899, £121,832. The imports in 1896 were £135,600; in 1898 they fell to £105,000, but in 1899 they showed improvement, standing at £109,031. The revenue in 1899 was £42,822, and the expenditure £51,959. The debt stood at £137,500 in 1900. Trade is chiefly with the United States. The tonnage entered and cleared at the various ports of the island was in 1898—steam, 409,122 (all British); sailing, 20,046 (of which 13,612 was British).

The islands Barbuda (680) and Redonda (120) produce phosphates of alumina.

Antilles, a term of somewhat doubtful origin now generally used, especially by foreign writers, as synonymous with the expression "West India Islands." Like "Brazil," it dates from a period anterior to the discovery of the New World, "Antilia" being one of those mysterious lands of the Gloomy Ocean, which figured on the mediæval charts sometimes as an archipelago, sometimes as continuous land of greater or lesser extent, constantly fluctuating in mid-ocean between the Canaries and East India. But it came at last to be identified with the land discovered by Columbus. Later, when this was found to consist of a vast archipelago enclosing the Caribbean sea and Gulf of Mexico, *Antilia* assumed its present plural form, *Antilles*, which was collectively applied to the whole of this archipelago. This theory fails to account for the origin of the term itself, which is supposed by some to be a corrupt form of the still older and more famous *Atlantis*. For the islands and groups now comprised under this designation, see WEST INDIES, and the separate entries—CUBA, JAMAICA, &c.

Antioch, (1) on the Orontes. The modern town, *Antákia*, stands in the north-western quarter of the ancient city, on the left bank of the el-Àsi, *Orontes*, on level ground at the foot of the rugged range of Mount Casius. More than half the town was destroyed by an earthquake in 1872, and the houses were rebuilt with material from the old walls. A marshy lake, in the fertile plain to the north, makes the town unhealthy, and the trade, in maize and liquorice root, is small. There is a British vice-consulate. The population consists of Moslems and Ansarieh, 16,000; Christians and Jews, 8000.

(2) PISIDIAN ANTIOCH was situated on the lower southern slopes of the Sultan Dagh, about 1¼ mile east of Yalovach, in the Konia vilâyet of Asia Minor, on the right bank of a stream, ancient *Anthius*, which flows into the Hoiran Geul. It was probably founded, on the site of a Phrygian sanctuary, by Seleucus Nicator, 301-280 B.C., and was made a free city by the Romans in 189 B.C. It was a thoroughly Hellenized, Greek-speaking city, in the midst of a Phrygian people, with a mixed population that included many Jews. Before 6 B.C. Augustus made it a colony with the title Cæsarea, and connected it with Lystra by the "Royal Road." Under Claudius, A.D. 41-54, when visited by Paul and Barnabas it was the civil and military centre of South Galatia, and a place of importance. In 1097 the Crusaders found rest and shelter within its walls. The ruins are interesting, and show that Antioch was a strongly-fortified city of Hellenic and Roman type (Ramsay, *St. Paul the Traveller: Historical Commentary on the Galatians*, 1899).

Antioquia, a department of the republic of Colombia, bounded on the N. by the Colombian departments of Bolivar and Cauca, on the E. by that of Santander and Boyaca, on the S. by those of Tolima and Cauca, and on the W. by Cauca. It has an area of 22,316 sq. miles, and its population is roughly estimated at about 500,000. The population of the capital, Medellin, is estimated at 40,000. The other principal towns are Marinilla, Sonson, Salamina, Santa Rosa, and Puerto Berrio.

ANTI-SEMITISM.

IN the political struggles of the concluding quarter of the 19th century an important part was played by a religious, political, and social agitation against the Jews, known as "Anti-Semitism." The origins of this remarkable movement already threaten to become obscured by legend. The Jews contend that anti-Semitism is a mere atavistic revival of the Jew-hatred of the Middle Ages. The extreme section of the anti-Semites, who have given the movement its quasi-scientific name, declare that it is a racial struggle—an incident of the eternal conflict between Europe and Asia—and that the anti-Semites are engaged in an effort to prevent what is called the Aryan race from being subjugated by a Semitic immigration, and to save Aryan ideals from being modified by an alien and demoralizing oriental *Anschauung*. There is no essential foundation for either of these contentions. Religious prejudices reaching back to the dawn of history have been reawakened by the anti-Semitic agitation, but they did not originate it, and they have not entirely controlled it. The alleged racial divergence is, too, only a linguistic hypothesis on the physical evidence of which anthropologists are not agreed (Topinard, *Anthropologie*, p. 444; Taylor, *Origins of Aryans*, cap. i.), and, even if it were proved, it has existed in Europe for so many centuries, and so many ethnic modifications have occurred on both sides, that it cannot be accepted as a practical issue. It is true that the ethnographical histories of the Jews and the nations of Europe have proceeded on widely diverging lines, but these lines have more than once crossed each other and become interlaced. Thus Aryan elements are at the beginnings of both; European morals have been ineradicably semitized by Christianity, and the Jews have been Europeans for over a thousand years, during which their character has been modified and in some respects transformed by the ecclesiastical and civil polities of the nations among whom they have made their permanent home. Anti-Semitism is then exclusively a question of European politics, and its origin is to be found, not in the long struggle between Europe and Asia, or between the Church and the Synagogue, which filled so much of ancient and mediæval history, but in the social conditions resulting from the emancipation of the Jews in the middle of the 19th century.

If the emancipated Jews were Europeans in virtue of the antiquity of their western settlements, and of the character impressed upon them by the circumstances of their European history, they none the less presented the appearance of a strange people to their Gentile fellow-countrymen. They had been secluded in their ghettos for centuries, and had consequently acquired a physical and moral physiognomy differentiating them in a measure from their former oppressors. This peculiar physiognomy was, on its moral side, not essentially Jewish or even Semitic. It was an advanced development of the main attributes of civilized life, to which Christendom in its transition from feudalism had as yet only imperfectly adapted itself. The ghetto, which had been designed as a sort of quarantine to safeguard Christendom against the Jewish heresy, had in fact proved a storage chamber for a portion of the political and social forces which were destined to sweep away the last traces of feudalism from central Europe. In the ghetto, the pastoral Semite, who had been made a wanderer by the destruction of his nationality, was steadily trained, through centuries, to become an urban European, with all the parasitic activities of urban economics, and all the democratic tendencies of occidental industrialism. Excluded from the army, the land, the trade corporations, and the artisan guilds, this quondam oriental peasant was gradually transformed into a commercial middleman and a practised dealer in money. Oppressed by the Church, and persecuted by the State, his theocratic and monarchical traditions lost their hold on his daily life, and he became saturated with a passionate devotion to the ideals of democratic politics. Finally, this former bucolic victim of Phœnician exploitation had his wits preternaturally sharpened, partly by the stress of his struggle for life, and partly by his being compelled in his urban seclusion to seek for recreation in literary exercises, chiefly the subtle dialectics of the Talmudists (Loeb, *Juif de l'Histoire;* Jellinek, *Jüdische Stamm*). Thus, the Jew who emerged from the ghetto was no longer a Palestinian Semite, but an essentially modern European, who differed from his Christian fellow-countrymen only in the circumstances that his religion was of the older Semitic form, and that his physical type had become sharply defined through a slightly more rigid exclusiveness in the matter of marriages than that practised by Protestants and Roman Catholics (Andree, *Volkskunde der Juden*, p. 58).

Unfortunately, these distinctive elements, though not very serious in themselves, became strongly accentuated by concentration. Had it been possible to distribute the emancipated Jews uniformly throughout Christian society, as was the case with other emancipated religious denominations, there would have been no revival of the Jewish question. The Jews, however, through no fault of their own, belonged to only one class in European society—the industrial *bourgeoisie.* Into that class all their strength was thrown, and owing to their ghetto preparation, they rapidly took a leading place in it, politically and socially. When the mid-century revolutions made the *bourgeoisie* the ruling power in Europe, the semblance of a Hebrew domination presented itself. It was the exaggeration of this apparent domination, not by the *bourgeoisie* itself, but by its enemies among the vanquished reactionaries on the one hand, and by the extreme Radicals on the other, which created modern anti-Semitism as a political force.

Germany.

The movement took its rise in Germany and Austria. Here the concentration of the Jews in one class of the population was aggravated by their excessive numbers. While in France the proportion to the total population was, in the early 'seventies, 0·14 per cent., and in Italy, 0·12 per cent., it was 1·22 per cent. in Germany, and 3·85 per cent. in Austria-Hungary; Berlin had 4·36 per cent. of Jews, and Vienna 6·62 per cent. (Andree, *Volkskunde*, pp. 287, 291, 294, 295). The activity of the Jews consequently manifested itself in a far more intense form in these countries than elsewhere. This was apparent even before the emancipations of 1848. Towards the middle of the 18th century, a limited number of wealthy Jews had been tolerated as *Schutz-Juden* outside the ghettos, and their sons, educated as Germans under the influence of Moses Mendelssohn and his school (JEWS, MODERN, *Ency. Brit.* xiii. p. 680), supplied a majority of the leading spirits of the revolutionary agitation. To this period belong the formidable names of Ludwig Boerne (1786-1837), Heinrich Heine (1799-1854), Edward Ganz (1798-1839), Gabriel Riesser (1806-1863), Ferdinand Lassalle (1825-1864), Karl Marx (1818-1883), Moses Hess (1812-1875), Ignatz Kuranda (1811-1884), and Johann Jacoby (1805-1877). When the revolution was completed, and the Jews entered in a body the national life of Germany and Austria, they sustained this high average in all the intellectual branches of middle-class activity. Here again, owing to the accidents of their history, a further concentration became apparent. Their activity was almost exclusively intellectual. The bulk of them flocked to the financial and the distributive (as distinct from the productive) fields of industry to which they had been confined in the ghettos. The sharpened faculties of the younger generation at the same time carried everything before them in the schools, with the result that they soon crowded the professions, especially medicine, law, and journalism (Nossig, *Statistik des Jüd. Stammes*, pp. 33-37; Jacobs, *Jew. Statistics*, pp. 41-69). Thus the "Semitic domination," as it was afterwards called, became every day more strongly accentuated. If it was a long time in exciting resentment and jealousy, the reason was that it was in no sense alien to the new conditions of the national life. The competition was a fair one. The Jews might be more successful than their Christian fellow-citizens, but it was in virtue of qualities which complied with the national standards of conduct. They were as law-abiding and patriotic as they were intelligent. Crime among them was far below the average (Nossig, p. 31). Their complete assimilation of the national spirit was brilliantly illustrated by the achievements in German literature, art, and science of such men as Heinrich Heine and Berthold Auerbach (1812-1882), Felix Mendelssohn (1809-1847), and Jacob Meyerbeer (1794-1864), Jacoby the mathematician (1804-1851), Valentin the physiologist (1808-1883), and Lazarus (b. 1824) and Steinthal (1823-1892) the national psychologists. In politics, too, Edward Lasker (1829-1884) and Ludwig Bamberger (b. 1823) had shown how Jews could put their country before party, when, at the turning-point of German Imperial history in 1866, they led the secession from the *Fortschritts-Partei* and founded the National Liberal party, which enabled Prince Bismarck to accomplish German unity. Even their financiers were not behind their Christian fellow-citizens in patriotism. Prince Bismarck himself confessed that the money for carrying on the 1866 campaign was obtained from the Jewish banker Bleichroeder, in face of the refusal of the money-market to support the war. Hence the voice of the old Jew-hatred—for in a weak way it was still occasionally heard in obscurantist corners—was shamed into silence, and it was only in the European twilight—in Russia and Rumania—and in lands where mediævalism still lingered, such as northern Africa and Persia, that oppression and persecution continued to dog the steps of the Jews.

The signal for the change came in 1873, and was given unconsciously by one of the most distinguished Jews of his time, Edward Lasker, the gifted lieutenant of Bennigsen in the leadership of the National Liberal party. The unification of Germany in 1870, and the rapid payment of the enormous French War indemnity, had given an unprecedented impulse to industrial and financial activity throughout the empire. Money became cheap and speculation became universal. A company mania set in which was favoured by the Government, who granted railway and other concessions with a prodigal hand. The inevitable result of this state of things was first indicated by Jewish politicians and economists. On the 14th January 1873, Edward Lasker called the attention of the Prussian Diet to the dangers of the situation, while his colleague, Ludwig Bamberger, in an able article in the *Preussischen Jahrbücher*, condemned the policy which had permitted the milliards to glut the country instead of being paid on a plan which would have facilitated their gradual digestion by the economic machinery of the nation. Deeply impressed by the gravity of the impending crisis, Lasker instituted a searching inquiry, with the result that he discovered a series of grave company scandals in which financial promoters and aristocratic directors were chiefly involved. Undeterred by the fact that the leading spirit in these abuses, Bethel Henry Strousberg, was a Jew, Lasker presented the results of his inquiry to the Diet on the 7th February 1873, in a speech of great power and full of sensational disclosures. The dramatic results of this speech need not be dwelt upon here (for details see Blum, *Deutsche Reich zur Zeit Bismarcks*, pp. 153-181). It must suffice to say that in the following May the great Vienna "Krach" occurred, and the colossal bubble of speculation burst, bringing with it all the ruin foretold by Lasker and Bamberger. From the position occupied by the Jews in the commercial class, and especially in the financial section of that class, it was inevitable that a considerable number of them should figure in the scandals which followed. At this moment an obscure Hamburg journalist, Wilhelm Marr, who as far back as 1862 had printed a still-born tract against the Jews (*Judenspiegel*), published a sensational pamphlet entitled *Der Sieg des Judenthums über das Germanenthum* ("The Victory of Judaism over Germanism"). The book fell upon fruitful soil. It applied to the nascent controversy a theory of nationality which, under the great sponsorship of Hegel, had seized on the minds of the German youth, and to which the stirring events of 1870 had already given a deep practical significance. The state, according to the Hegelians, should be national, and the nation should be a unit comprising individuals speaking the same language and of the same racial origin. Heterogeneous elements might be absorbed, but if they could not be reduced to the national type they should be eliminated. This was the pseudo-scientific note of the new anti-Semitism, the theory which differentiated it from the old religious Jew-hatred and sought to give it a rational place in modern thought. Marr's pamphlet, which reviewed the facts of the Jewish social concentration without noticing their essentially transitional character, proved the pioneer of this teaching. It was, however, in the passions of party politics that the new crusade found its chief sources of vitality. The enemies of the *bourgeoisie* at once saw that the movement was calculated to discredit and weaken the school of Manchester Liberalism, then in the ascendant. Agrarian capitalism, which had been dethroned by industrial capitalism in 1848, and had burnt its fingers in 1873, seized the opportunity of paying off old scores. The clericals, smarting under the *Kulturkampf*, which was supported by the whole body of Jewish liberalism, joined heartily in the new cry. In 1876 another sensational pamphlet was published, Otto Glagau's *Der Boersen und Grundergeschwindel in Berlin* ("The Bourses and the Company Swindles in Berlin"), dealing in detail with the Jewish participation in the scandals first revealed by Lasker. The agitation gradually swelled, its growth being helped by the sensitiveness and *cacoëthes scribendi* of the Jews themselves, who contributed two pamphlets and a much larger proportion of newspaper articles for every one supplied by their opponents (Jacobs, *Bibliog. Jew. Question*, p. xi.). Up to 1879, however, it was more of a literary than a political agitation, and was generally regarded only as an ephemeral craze or a passing spasm of popular passion.

Towards the end of 1879 it spread with sudden fury over the whole of Germany. This outburst, at a moment when no new financial scandals or other illustrations of Semitic demoralization and domination were before the public, has never been fully explained. It is impossible to doubt, however, that the secret springs of the new agitation were more or less directly supplied by Prince Bismarck himself. Since 1877 the relations between the chancellor and the National Liberals had gradually become strained. The deficit in the budget had compelled the Government to think of new taxes, and in order to carry them through the Reichstag the support of the National Liberals had been solicited. Until then the National Liberals had faithfully supported the chancellor in nursing the consolidation of the new empire, but the great dream of its leaders, especially of Lasker and Bamberger, who had learnt their politics in England, was to obtain a constitutional and economic *régime* similar to that of the British Isles. The organization of German unity was now completed, and they regarded the new overtures of Prince Bismarck as an opportunity for pressing their constitutional demands. These were refused, the Reichstag was dissolved, and Prince Bismarck boldly came forward with a new fiscal policy, a combination of protection and state socialism. Lasker and Bamberger thereupon led a powerful secession of National Liberals into opposition, and the chancellor was compelled to seek a new majority among the ultra-Conservatives and the Roman Catholic Centre. This was the beginning of the famous "journey to Canossa." Bismarck did not hide his mortification. He began to recognize in anti-Semitism a means of "dishing" the Judaized liberals, and to his creatures who assisted him in his press campaigns he dropped significant hints in this sense (Busch, *Bismarck*, ii. 453-54, iii. 16). He even spoke of a new *Kulturkampf* against the Jews (*ibid.* ii. p. 484). How these hints were acted upon has not been revealed, but it is sufficiently instructive to notice that the final breach with the National Liberals took place in July 1879, and that it was immediately followed by a violent revival of the anti-Semitic agitation. Marr's pamphlet was reprinted, and within a few months ran through nine further editions. The historian Treitschke gave the sanction of his great name to the movement. The Conservative and Ultramontane press rang with the sins of the Jews. In October an anti-Semitic league was founded in Berlin and Dresden (for statutes of the league see *Nineteenth Century*, February 1881, p. 344).

The leadership of the agitation was now definitely assumed by a man who combined with social influence, oratorical power, and inexhaustible energy, a definite scheme of social regeneration and an organization for carrying it out. This man was Adolf Stoecker (b. 1835), one of the Court Preachers. He had embraced the doctrines of Christian Socialism which the Roman Catholics, under the guidance of Archbishop Ketteler, had adopted from the teachings of the Jew Lassalle (Nitti, *Catholic Socialism*, pp. 94-96, 122, 127), and he had formed a society called "The Christian Social Working-man's Union." He was also a conspicuous member of the Prussian Diet, where he sat and voted with the Conservatives. He found himself in strong sympathy with Prince Bismarck's new economic policy, which, although also of Lassallian origin (Kohut, *Ferdinand Lassalle*, pp. 144 *et seq.*), was claimed by its author as being essentially Christian (Busch, p. 483). Under his auspices the years 1880-81 became a period of bitter and scandalous conflict with the Jews. The Conservatives supported him, partly to satisfy their old grudges against the Liberal *bourgeoisie* and partly because Christian Socialism, with its anti-Semitic appeal to ignorant prejudice, was likely to weaken the hold of the Social Democrats on the lower classes. The Lutheran clergy followed suit, in order to prevent the Roman Catholics from obtaining a monopoly of Christian Socialism, while the Ultramontanes readily adopted anti-Semitism, partly to maintain their monopoly, and partly to avenge themselves on the Jewish and Liberal supporters of the *Kulturkampf*. In this way a formidable body of public opinion was recruited for the anti-Semites. Violent debates took place in the Prussian Diet. A petition to exclude the Jews from the national schools and universities and to disable them from holding public appointments was presented to Prince Bismarck. Jews were boycotted and insulted. Duels between Jews and anti-Semites, many of them fatal, became of daily occurrence. Even unruly demonstrations and street riots were reported. Pamphlets attacking every phase and aspect of Jewish life streamed by the hundred from the printing-press. On their side the Jews did not want for friends, and it was owing to the strong attitude adopted by the Liberals that the agitation failed to secure legislative fruition. The crown prince (afterwards Emperor Frederick) and crown princess boldly set themselves at the head of the party of protest. The crown prince publicly declared that the agitation was "a shame and a disgrace to Germany." A manifesto denouncing the movement as a blot on German culture, a danger to German unity, and a flagrant injustice to the Jews themselves, was signed by a long list of illustrious men, including Herr von Forckenbeck, Professors Mommsen, Gneist, Droysen, Virchow, and Dr. Werner Siemens (*Times*, Nov. 18, 1880). During the Reichstag elections of 1881 the agitation played an active part, but without much effect, although Stoecker was elected. This was due to the fact that the great Conservative parties, so far as their political organizations were concerned, still remained chary of publicly identifying themselves with a movement which, in its essence, was of socialistic tendency. Hence the electoral returns of that year supplied no sure guide to the strength of anti-Semitic convictions among the German people.

The first severe blow suffered by the German anti-Semites was in 1882, when, to the indignation of the whole civilized world, the barbarous riots against the Jews in Russia and the revival of the mediæval Blood Accusation in Hungary (see *infra*) illustrated the liability of unreasoning mobs to carry into violent practice the incendiary doctrines of the new Jew-haters. From this blow anti-Semitism might have recovered had it not been for the divisions and scandals in its own ranks, and the artificial forms it subsequently assumed through factitious alliances with political parties bent less on persecuting the Jews than on profiting by the anti-Jewish agitation. The divisions showed themselves at the first attempt to form a political party on an anti-Semitic basis. Imperceptibly the agitators had grouped themselves into two classes, economic and ethnological anti-Semites. The impracticable racial views of Marr and Treitschke had not found favour with Stoecker and the Christian Socialists. They were disposed to leave the Jews in peace so long as they behaved themselves properly, and although they carried on their agitation against Jewish malpractices in a comprehensive form which seemed superficially to identify them with the root-and-branch anti-Semites, they were in reality not inclined to accept the racial theory with its scheme of revived Jewish disabilities (Huret, *La Question Sociale*—interview with Stoecker). This feeling was strengthened by a tendency on the part of an extreme wing of the racial anti-Semites to extend their campaign against Judaism to its offspring, Christianity. In 1879 Professor Sepp, arguing that Jesus was of no human race, had proposed that Christianity should reject the Hebrew Scriptures and seek a fresh historical basis in the cuneiform inscriptions. Later Dr Dühring, in several brochures, notably *Die Judenfrage als Racen, Sitten und Cultur Frage* (1881), had attacked Christianity as a manifestation of the Semitic spirit which was not compatible with the theological and ethical conceptions of the Scandinavian peoples. The philosopher Friedrich Nietzsche had also adopted the same view without noticing that it was a *reductio ad absurdum* of the whole agitation. (*Menschliches, Allzumenschliches* (1878), *Jenseits von Gut und Böse* (1886), *Genealogie der Moral* (1887).) With these tendencies the Christian Socialists could have no sympathy, and the consequence was that when in March 1881 a political organization of anti-Semitism was attempted, two rival bodies were created, the "Deutsche Volksverein," under the Conservative auspices of Herr Liebermann von Sonnenberg (b. 1848) and Herr Foerster, and the "Sociale Reichsverein," led by the racial and Radical anti-Semites, Ernst Henrici (b. 1854) and Otto Boeckl (b. 1859). In 1886, at an anti-Semitic congress held at Cassel a reunion was effected under the name of the "Deutsche antisemitische Verein," but this only lasted three years. In June 1889 the anti-Semitic Christian Socialists under Stoecker again seceded.

Meanwhile racial anti-Semitism with its wholesale radical proposals had been making considerable progress among the ignorant lower classes. It adapted itself better to popular passions and inherited prejudice than the more academic conceptions of the Christian Socialists. The latter, too, were largely Conservatives, and their points of contact with the proletariat were at best artificial. Among the Hessian peasantry the inflammatory appeals of Boeckl secured many adherents. This paved the way for a new anti-Semitic leader, Herrmann Ahlwardt (b. 1846), who, towards the end of the 'eighties, eclipsed all the other anti-Semites by the sensationalism and violence with which he prosecuted the campaign. Ahlwardt was a person of evil notoriety. He was loaded with debt. In the Manché decoration scandals it was proved that he had acted first as a corrupt intermediary and afterwards as the betrayer of his confederates. His anti-Semitism was adopted originally as a means of *chantage*, and it was only when it failed to yield profit in this form that he came out boldly as an agitator. The wildness, unscrupulousness, and full-bloodedness of his propaganda enchanted the mob, and he bid fair to become a powerful democratic leader. His pamphlets, full of scandalous revelations of alleged malpractices of eminent Jews, were read with avidity. No fewer than ten of them were written and published during 1892. Over and over again he was prosecuted for libel and convicted, but this seemed only to strengthen his influence with his followers. The Roman Catholic clergy and newspapers helped to inflame the popular passions. The result was that anti-Jewish riots broke out. At Neustettin the Jewish synagogue was burnt, and at Xanton the Blood Accusation was revived, and a Jewish butcher was tried on the ancient charge of murdering a Christian child for ritual purposes. The man was, of course, acquitted, but the symptoms it revealed of reviving mediævalism strongly stirred the liberal and cultured mind of Germany. All protest, however, seemed powerless, and the barbarian movement appeared destined to carry everything before it.

German politics at this moment were in a very intricate state. Prince Bismarck had retired, and Count Caprivi, with a programme of general conciliation based on Liberal principles, was in power. Alarmed by the non-renewal of the anti-Socialist law, and by the conclusion of commercial treaties which made great concessions to German industry, the landed gentry and the Conservative party became alienated from the new chancellor. In January 1892 the split was completed by the withdrawal by the Government of the Primary Education Bill, which had been designed to place primary instruction on a religious basis. The Conservatives saw their opportunity of posing as the party of Christianity against the Liberals and Socialists, who had wrecked the Bill, and they began to look towards Ahlwardt as a possible ally. He had the advantages over Stoecker that he was not a Socialist, and that he was prepared to lead his apparently large following to assist the agrarian movement and weaken the Social Democrats. The intrigue gradually came to light. Towards the end of the year Herr Liebknecht, the Social Democratic leader, denounced the Conservatives to the Reichstag as being concerned "in using the anti-Semitic movement as a bastard edition of Socialism for the use of stupid people" (1st December). Two days later the charge was confirmed. At a meeting of the party held on 3rd December the following plank was added to the Conservative programme: "We combat the oppressive and disintegrating Jewish influence on our national life; we demand for our Christian people a Christian magistracy and Christian teachers for Christian pupils; we repudiate the excesses of anti-Semitism." In pursuance of this resolution Ahlwardt was returned to the Reichstag at a by-election by the Conservative district of Arnswalde-Friedeberg. The coalition was, however, not yet completed. The intransigeant Conservatives, led by Baron von Hammerstein, the editor of the *Kreuz-Zeitung*, justly felt that the concluding sentence of the resolution of 3rd December repudiating "the excesses of anti-Semitism" was calculated to hinder a full and loyal co-operation between the two parties. Accordingly on 9th December another meeting of the party was summoned. Twelve hundred members met at the Tivoli Hall in Berlin, and with only seven dissentients solemnly expunged the offending sentence from the resolution. The history of political parties may be searched in vain for a parallel to this discreditable transaction.

The capture of the Conservative party proved the high-water mark of German anti-Semitism. From that moment the tide began to recede. All that was best in German national life was scandalized by the cynical tactics of the Conservatives. The emperor, strong Christian though he was, was shocked at the idea of serving Christianity by a compact with unscrupulous demagogues and ignorant fanatics. Prince Bismarck growled out a stinging sarcasm from his retreat at Friedrichsruh. Even Stoecker raised his voice in protest against the "Ahlwardtismus" and "Boeckelianismus," and called upon his Conservative colleagues to distinguish between "respectable and disreputable anti-Semitism." As for the Liberals and Socialists, they filled the air with bitter laughter, and declared from the housetops that the stupid party had at last been overwhelmed by its own stupidity. The Conservatives began to suspect that they had made a false step, and they were confirmed in this belief by the conduct of their new ally in the Reichstag. His début in parliament was the signal for a succession of disgraceful scenes. His whole campaign of calumny was transferred to the floor of the house, and for some weeks the Reichstag discussed little else than his so-called revelations. The Conservatives listened to his wild charges in uncomfortable silence, and refused to support him. Stoecker opposed him in a violent speech. The Radicals and Socialists, taking an accurate measure of the shallow vanity of the man, adopted the policy of giving him "enough rope." Shortly after his election he was condemned to five months' imprisonment for libel, and he would have been arrested but for the interposition of the Socialist party, including five Jews, who claimed for him the immunities of a member of parliament. When he moved for a commission to inquire into his revelations, it was again the Socialist party which supported him, with the result that all his charges, without exception, were found to be absolutely baseless. Ahlwardt was covered with ridicule, and when in May the Reichstag was dissolved, he was marched off to prison to undergo the sentence for libel from which his parliamentary privilege had up to that moment protected him.

His hold on the anti-Semitic populace was, however, not diminished. On the contrary, the action of the Conservatives at the Tivoli Congress could not be at once eradicated from the minds of the Conservative voters, and when the electoral campaign began it was found impossible to explain to them that the party leaders had changed their minds. The result was that Ahlwardt, although in prison, was elected by two constituencies. At Arnswalde Friedeberg he was returned in the teeth of the opposition of the official Conservatives, and at Neu-Stettin he defeated no less a person than his anti-Semitic opponent Stoecker. Seventeen other anti-Semites, all of the Ahlwardtian school, were elected. This, however, represented the extreme strength of the anti-Semitic party in Germany; for henceforth it had to stand alone as one of the many minor factions in the Reichstag, avoided by all the great parties, and too weak to exercise any influence on the main course of affairs.

During the subsequent seven years it became more and more discredited. The financial scandals connected with Foerster's attempt to found a Christian Socialist colony in Paraguay, the conviction of Baron von Hammerstein, the anti-Semitic Conservative leader, of forgery and swindling (1895-96), and several minor scandals of the same unsavoury character, covered the party with the very obloquy which it had attempted to attach to the Jews. At the same time the Christian Socialists who had remained with the Conservative party also suffered. After the elections of 1893, Stoecker was dismissed from his post of Court Preacher, and publicly reprimanded for speaking familiarly of the empress. Two years later the Christian Socialist Pastor Neumann, observing the tendency of the Conservatives to coalesce with the moderate Liberals in antagonism to Social Democracy, declared against the Conservative party. The following year the emperor publicly condemned Christian Socialism and the "political pastors," and Stoecker was expelled from the Conservative party for refusing to modify the socialistic propaganda of his organ, *Das Volk*. His fall was completed by a quarrel with the Evangelical Social Union. He left the Union and appealed to the Lutheran clergy to found a new Church social organization, but met with no response. Another blow to anti-Semitism came from the Roman Catholics. They had become alarmed by the unbridled violence of the Ahlwardtians, and when in 1894 Foerster declared in an address to the German anti-Semitic Union that anarchical outrages like the murder of president Carnot were as much due to the "Anarchismus von oben" as the "Anarchismus von unten," the Ultramontane *Germania* publicly washed its hands of the Jew-baiters (1st July 1894). Thus gradually German anti-Semitism became stripped of every adventitious alliance;

and although at the general election of 1898 it managed still to return twelve members to the Reichstag, it had ceased to be regarded as a serious element in politics.

The causes of the decline of German anti-Semitism are not difficult to determine. While it remained a theory of nationality and a fad of the metaphysicians, it made considerable noise in the world, but without exercising much practical influence. When it attempted to play an active part in politics it became submerged by the ignorant and superstitious voters, who could not understand its scientific justification, but who were quite ready to declaim and riot against the Jew bogey. It thus became a sort of Jacquerie which, being exploited by unscrupulous demagogues, soon alienated all its respectable elements. Its moments of real importance were due not to inherent strength but to the uses made of it by other political parties for their own purposes. These coalitions are no longer possible, not only because anti-Semitism has ceased to be respectable, but because, in face of the growing strength of Democratic Socialism, all supporters of the present organization of society have found it necessary to sink their differences. The new social struggle has eclipsed the racial theory of nationality. The Social Democrat is now the enemy, and the new reaction counts on the support of the rich Jews and the strongly individualist Jewish middle class to assist it in preserving the existing social structure.

Russia.

More serious have been the effects of German anti-Semitic teachings on the political and social life of the countries adjacent to the empire—Russia, Austria, and France. In Russia these effects were first seriously felt owing to the fury of autocratic reaction to which the tragic death of the Tsar Alexander II. gave rise. This, however, like the Strousberg *Krach* in Germany, was only the proximate cause of the outbreak. There were other elements which had created a *milieu* peculiarly favourable to the transplantation of the German craze. In the first place the mediæval anti-Semitism was still an integral part of the polity of the empire. The Jews were cooped up in one huge ghetto in the western provinces, "marked out to all their fellow-countrymen as aliens and a pariah caste set apart for special and degrading treatment" (*Persecution of the Jews in Russia*, 1891, p. 5). In the next place, owing to the emancipation of the serfs which had half ruined the land-owners, while creating a free but moneyless peasantry, the Jews, who could be neither nobles nor peasants, had found a vocation as money-lenders and as middlemen between the grain producers and the grain consumers and exporters. There is no evidence that this function was performed, as a rule, in an exorbitant or oppressive way. On the contrary, the fall in the value of cereals on all the provincial markets, after the riots of 1881, shows that the Jewish competition had previously assured full prices to the farmers (Schwabacher, *Denkschrift*, 1882, p. 27). Nevertheless, the Jewish activity or "exploitation," as it was called, was resented, and the ill-feeling it caused among land-owners and farmers was shared by non-Jewish middlemen and merchants who had thereby been compelled to be satisfied with small profits. Still there was but little thought of seeking a remedy in an organized anti-Jewish movement. On the contrary, the abnormal situation aggravated by the disappointments and depression caused by the Turkish war, had stimulated a widespread demand for constitutional changes which would enable the people to adopt a state-machinery more exactly suited to their needs. Among the peasantry this demand was promoted and fomented by the Nihilists, and among the land-owners it was largely adopted as a means of checking what threatened to become a new Jacquerie (Walcker, *Gegenwärtige Lage Russlands*, 1873; *Innere Krisis Russlands*, 1876). The tsar, Alexander II., strongly sympathized with this movement, and on the advice of Count Loris Melikoff and the council of ministers a rudimentary scheme of parliamentary government had been drafted and actually signed when the emperor was assassinated. Meanwhile a nationalist and reactionary agitation, originating like its German analogue in the Hegelianism of a section of the lettered public, had manifested itself in Moscow. After some early vicissitudes, it had been organized, under the auspices of Alexis Kireieff, Chomjakoff, Aksakoff, and Kocheleff, into the Slavophil party, with a Romanticist programme of reforms based on the old traditions of the pre-Petrine epoch. This party gave a great impetus to Slav nationalism. Its final possibilities were sanguinarily illustrated by Muravieff's campaign in Poland in 1863, and in the war against Turkey in 1877, which was exclusively its handiwork (Statement by General Kireieff: Schütz, *Das heutige Russland*, p. 104). After the assassination of Alexander II. the Slavophil teaching, as expounded by Ignatieff and Pobyedonostzeff, became paramount in the Government, and the new tsar was persuaded to cancel the constitutional project of his father. The more liberal views of a section of the Slavophils under Aksakoff, who had been in favour of representative institutions on traditional lines, were displaced by the reactionary system of Pobyedonostzeff, who took his stand on absolutism, orthodoxy, and the racial unity of the Russian people. This was the situation on the eve of Easter 1881. The hardening nationalism above, the increasing discontent below, the economic activity of the Hebrew heretics and aliens, and the echoes of anti-Semitism from over the western border were combining for an explosion.

A scuffle in a tavern at Elisabethgrad, in Kherson, sufficed to ignite this combustible material. The scuffle grew into a riot, the tavern was sacked, and the drunken mob, hounded on by agitators who declared that the Jews were using Christian blood for the manufacture of their Easter bread, attacked and looted the Jewish quarter. The outbreak rapidly spread. On 7th May there was a similar riot at Smiela, near Czergassy, and the following day there was a violent outbreak at Kieff, which left 2000 Jews homeless. Within a few weeks the whole of Western Russia, from the Black Sea to the Baltic, was smoking with the ruins of Jewish homes. Scores of Jewish women were dishonoured, hundreds of men, women and children were slaughtered, and tens of thousands were reduced to beggary and left without a shelter. Murderous riots or incendiary outrages took place in no fewer than 167 towns and villages, including Warsaw, Odessa, and Kieff. Europe had witnessed no such scenes of mob savagery since the Black Death massacres in the fourteenth century. As the facts gradually filtered through to the western capitals they caused a thrill of horror everywhere. An indignation meeting held at the Mansion House in London, under the presidency of the Lord Mayor, was the signal for a long series of popular demonstrations condemning the persecutions, held in most of the chief cities of England and the Continent.

Except as stimulated by the Judeophobe revival in Germany the Russian outbreak in its earlier forms does not belong specifically to modern anti-Semitism. It was essentially a mediæval uprising animated by the religious fanaticism, gross superstition, and predatory instincts of a people still in the mediæval stage of their development. This is proved by the fact that, although the Russian peasant was supposed to be a victim of unbearable Jewish "exploitation," he was not moved to riot until he had been brutalized by drink and excited by the old fable of the Blood Accusation. The modern anti-Semitic element came from above, and followed closely on the heels of the riots. It has been freely charged against the Russian Government that it promoted the riots in 1881 in order to distract popular attention from the Nihilist propaganda and from the political disappointments involved in the cancellation of the previous tsar's constitutional project (Lazare, *L'Antisémitisme*, p. 211). This is an hypothesis which will not stand the test of investigation. It is true that the local authorities, both civil and military, favoured the outbreak, and took no steps to suppress it, but this may be accounted for by the fact that the feudal bureaucracy had just escaped a great danger, and were consequently not sorry to see the discontented populace venting their passions on the Jews. In the higher circles of the Government different views prevailed. The tsar himself was at first persuaded that the riots were the work of Nihilists, and he publicly promised his protection to the Jews. On the other hand, his ministers, ardent Slavophils, thought they recognized in the outbreak an endorsement of the nationalist teaching of which they were the apostles, and, while reprobating the acts of violence, came to the conclusion that the most reasonable solution was to aggravate the legal disabilities of the persecuted aliens and heretics. To this view the tsar was won over, partly by the clamorous indignation of Western Europe, which had wounded his national *amour propre* to the quick, and partly by the strongly partisan report of a commission appointed to inquire, not into the administrative breakdown which had allowed riot to run loose over the western and southern provinces, but into the "exploitation" alleged against the Jews, the reasons why "the former laws limiting the rights of the Jews" had been mitigated, and how these laws could be altered so as "to stop the pernicious conduct of the Jews" (Rescript of 3rd September 1881). The result of this report was the drafting of a "Temporary Order concerning the Jews" by the Minister of the Interior, Count Ignatieff, which received the assent of the tsar on the 3rd May 1882. This order, which was so little temporary that it has not yet been repealed, had the effect of creating a number of fresh ghettos within the pale of Jewish settlement. The Jews were cooped up within the towns, and their rural interests were arbitrarily confiscated. The doubtful incidence of the order gave rise to a number of judgments of the Senate, by which all its persecuting possibilities were brought out, with the result that the activities of the Jews were completely paralysed, and they became a prey to unparalleled cruelty. As the gruesome effect of this legislation became known, a fresh outburst of horror and indignation swelled up from Western Europe. It proved powerless. Count Ignatieff was dismissed owing to the protests of high-placed Russians, who were disgusted by the new *Kulturkampf*, but his work remained, and, under the influence of M. Pobyedonostzeff, the Procurator of the Holy Synod, the policy of the "May Laws," as they were significantly called, was applied to every aspect of Jewish life with pitiless rigour. The temper of the tsar may be judged by the fact that when an appeal for mercy from an illustrious personage in England was conveyed to him at Fredensborg through the gracious medium of the tsaritza, his Majesty angrily exclaimed within the hearing of an Englishman in the ante-room who was the bearer of the message, "Never let me hear you mention the name of that people again!"

The Russian May Laws are the most conspicuous legislative monument achieved by modern anti-Semitism. It is true that they re-enacted regulations which resemble the oppressive statutes introduced into Poland through the influence of the Jesuits in the 16th century (Sternberg, *Gesch. d. Juden in Polen*, pp. 141 *et seqq.*), but their orthodox authors were as little conscious of this irony of history as they were of the Teutonic origins of the whole Slavophil movement. These laws are an experimental application of the political principles extracted by Marr and his German disciples from the metaphysics of Hegel, and as such they afford a valuable means of testing the practical operation of modern anti-Semitism. Their result was a widespread commercial depression which was felt all over the empire. Even before the May Laws were definitely promulgated the passport registers showed that the anti-Semitic movement had driven 67,900 Jews across the frontier, and it was estimated that they had taken with them 13,000,000 roubles, representing a minimum loss of 60,000,000 roubles to the annual turnover of the country's trade. Towards the end of 1882 it was calculated that the agitation had cost Russia as much as the whole Turkish war of 1877. Trade was everywhere paralysed. The enormous increase of bankruptcies, the transfer of investments to foreign funds, the consequent fall in the value of the rouble and the prices of Russian stocks, the suspension of farming operations owing to advances on growing crops being no longer available, the rise in the prices of the necessaries of life, and lastly, the appearance of famine, filled half the empire with gloom. Banks closed their doors, and the great provincial fairs proved failures. When it was proposed to expel the Jews from Moscow there was a loud outcry all over the Sacred City, and even the Orthodox merchants, realizing that the measure would ruin their flourishing trade with the south and west, petitioned against it. The Moscow Exhibition proved a failure. Nevertheless the Government persisted with its harsh policy, and Jewish refugees streamed by tens of thousands across the western frontier to seek an asylum in other lands. In 1891 the alarm caused by this emigration led to further protests from abroad. The citizens of London again assembled at Guildhall, and addressed a petition to the tsar on behalf of his Hebrew subjects. It was handed back to the Lord Mayor by the Russian Ambassador, with a curt intimation that the emperor declined to receive it. At the same time orders were defiantly given that the May Laws should be strictly enforced. Meanwhile the Russian Minister of Finance was at his wits' ends for money. Negotiations for a large loan had been entered upon with the house of Rothschild, and a preliminary contract had been signed, when, at the instance of the London firm, M. Wyshnigradski, the Finance Minister, was informed that unless the persecutions of the Jews were stopped the great banking-house would be compelled to withdraw from the operation. Deeply mortified by this attempt to deal with him *de puissance à puissance*, the tsar peremptorily broke off the negotiations, and ordered that overtures should be made to a non-Jewish French syndicate. In this way anti-Semitism, which had already so profoundly influenced the domestic politics of Europe, set its mark on the international relations of the Powers, for it was the urgent need of the Russian Treasury quite as much as the termination of Prince Bismarck's secret treaty of mutual neutrality which brought about the Franco-Russian alliance (Daudet, *Hist. Dipl. de l'Alliance Franco-Russe*, pp. 259 *et seqq.*).

For nearly three years more the persecutions continued. Elated by the success of his crusade against the Jews, M. Pobyedonostzeff extended his persecuting policy to other non-Orthodox denominations. The legislation against the Protestant Stundists became almost as unbearable as that imposed on the Jews. In the report of the Holy Synod, presented to the tsar towards the end of 1893, the procurator called for repressive measures against Roman

Catholics, Moslems, and Buddhists, and denounced the rationalist tendency of the whole system of secular education in the empire (*Neue Freie Presse*, 31st January 1894). A year later, however, the tsar died, and his successor, without repealing any of the persecuting laws, let it gradually be understood that their rigorous application might be mitigated. The country was tired and exhausted by the persecution, and the tolerant hints which came from high quarters were acted upon with significant alacrity. This tolerant tendency has since been strengthened by a new political movement, inaugurated by Prince Oukhtomsky, the apostle of Russian Asiatic Imperialism. The Prince dreams of a future when the tsar will rule over the whole of Asia, but he realizes that this mission must be based on the most generous principles of religious toleration (Leger, *Russes et Slaves*, 3^{me} Serie, pp. 79-81). As a personal friend of the new tsar his teachings in this sense have produced considerable effect throughout Russian society, and have helped to mitigate the terrible lot of the Jews.

Rumania.

The only other country in Europe in which a legalized anti-Semitism exists is Rumania. The conditions are very similar to those which obtain in Russia, with the important difference that Rumania is a constitutional country, and that the Jewish persecutions are the work of the elected deputies of the nation. Like the *Bourgeois Gentilhomme* who wrote prose all his life without knowing it, the Rumanians practised the nationalist doctrines of the Hegelian anti-Semites unconsciously long before they were formulated in Germany. In the old days of Turkish domination the lot of the Rumanian Jews was not conspicuously unhappy. It was only when the nation began to be emancipated, and the struggle in the East assumed the form of a crusade against Islam that the Jews were persecuted. Rumanian politicians preached a nationalism limited exclusively to indigenous Christians, and they were strongly supported by all who felt the commercial competition of the Jews. Thus, although the Jews had been settled in the land for many centuries they were by law declared aliens. This was done in defiance of the Treaty of Paris of 1856 and the Convention of 1858 which declared all Rumans to be equal before the law. Under the influence of this distinction the Jews became persecuted, and sanguinary riots were of frequent occurrence. The realization of a Jewish question led to legislation imposing disabilities on the Jews. In 1878 the Berlin Congress agreed to recognize the independence of Rumania on condition that all religious disabilities were removed. Rumania agreed to this condition, but ultimately persuaded the Powers to allow her to carry out the emancipation of the Jews gradually. During the years which have elapsed since then, the condition of the Jews has been in no way improved. Their emancipation is as far off as ever, and their disabilities are heavier than those of their brethren in Russia. For this state of things the example of the anti-Semites in Germany, Russia, Austria, and France is largely to blame, since it has justified the intolerance of the Rumans. Owing, also, to the fact that of late years Rumania has become a sort of *annexe* of the Triple Alliance, it has been found impossible to induce the signatories of the Berlin Treaty to take action to compel the state to fulfil its obligations under that treaty.

Austria-Hungary.

In Austria-Hungary the anti-Semitic impulses came almost simultaneously from the North and East. Already in the 'seventies the doctrinaire anti-Semitism of Berlin had found an echo in Budapest. Two members of the Diet, Victor Istoczy and Geza Onody, together with a publicist named Georg Marczianyi, busied themselves in making known the doctrine of Marr in Hungary. Marczianyi, who translated the German Judeophobe pamphlets into Magyar, and the Magyar works of Onody into German, was the chief medium between the northern and southern schools. In 1880 Istoczy tried to establish a "Nichtjuden Bund" in Hungary, with statutes literally translated from those of the German anti-Semitic league. The movement, however, made no progress, owing to the stalwart Liberalism of the predominant political parties, and of the national principles inherited from the Revolution. The large part played by the Jews in the struggle of 1848, and the fruitful patriotism with which they had worked for the political and economic progress of the country, had created, too, a strong claim on the gratitude of the best elements in the nation. Nevertheless, among the Ultramontane clergy, the higher aristocracy, the ill-paid minor officials, and the ignorant peasantry, the seeds of a tacit anti-Semitism were latent. It was probably the aversion of the nobility from anything in the nature of a demagogic agitation which for a time prevented these seeds from germinating. The news of the uprising in Russia and the appearance of Jewish refugees on the frontier, had the effect of giving a certain prominence to the agitation of Istoczy and Onody and of exciting the rural communities, but it did not succeed in impressing the public with the pseudo-scientific doctrines of the new anti-Semitism. It was not until the agitators resorted to the Blood Accusation — that never-failing decoy of obscurantism and superstition—that Hungary took a definite place in the anti-Semitic movement. The outbreak was short and fortunately bloodless, but while it lasted its scandals shocked the whole of Europe.

Dr August Rohling, Professor of Hebrew at the University of Prague, a Roman Catholic theologian of high position but dubious learning, had for some years assisted the Hungarian anti-Semites with *réchauffés* of Eisenmenger's *Entdecktes Judenthum* (Frankfurt a/M 1700). In 1881 he made a solemn deposition before the Supreme Court accusing the Jews of being bound by their law to work the moral and physical ruin of non-Jews. He followed this up with an offer to depose on oath that the murder of Christians for ritual purposes was a doctrine secretly taught among Jews. Professor Delitzsch and other eminent Hebraists, both Christian and Jewish, exposed and denounced the ignorance and malevolence of Rohling, but were unable to stem the mischief he was causing. In April 1882 a Christian girl named Esther Solymossi was missed from the Hungarian village of Tisza Eszlar, where a small community of Jews were settled. The rumour got abroad that she had been kidnapped and murdered by the Jews, but it remained the burden of idle gossip, and gave rise to neither judicial complaint nor public disorders. At this moment the question of the Bosnian Pacification credits was before the Diet. The unpopularity of the task assumed by Austria-Hungary, under the Treaty of Berlin, which was calculated to strengthen the disaffected Croat element in the empire, had reduced the Government majority to very small proportions, and all the reactionary factions in the country were accordingly in arms. The Government was violently and unscrupulously attacked on all sides. On the 23rd May there was a debate in the Diet when M. Onody, in an incendiary harangue, told the story of the missing girl at Tisza Eszlar, and accused ministers of criminal indulgence to races alien to the national spirit. In the then excited state of the public mind on the Croat question, the manœuvre was adroitly conceived. The Government fell into the trap, and treated the story with lofty disdain. Thereupon the anti-Semites set to work on the case, and M. Joseph Bary, the magistrate at Nyiregyhasa, and a noted anti-Semite, was induced to go to Tisza Eszlar and institute an inquiry. All the anti-Liberal elements in the country now became banded together in this effort to discredit the Liberal Government, and for the first time the Hungarian anti-Semites found themselves at the head of a powerful party. Fifteen Jews were arrested and thrown into prison. No pains were spared in preparing the case for trial. Perjury and even forgery were freely resorted to. The son of one of the accused, a boy of fourteen, was taken into custody by the police, and by threats and cajoleries prevailed upon to give evidence for the prosecution. He was elaborately coached for the terrible *rôle* he was to play. The trial opened at Nyiregyhasa on the 19th June, and lasted till the 3rd August. It was one of the most dramatic *causes célèbres* of the century. Under the brilliant cross-examination of the advocates for the defence the whole of the shocking conspiracy was gradually exposed. The public prosecutor thereupon withdrew from the case, and the four judges—the chief of whom held strong anti-Semitic views—unanimously acquitted all the prisoners. The case proved the death-blow of Hungarian anti-Semitism. Although another phase of the Jewish question, which will be referred to presently, had still to occupy the public mind, the shame brought on the nation by the Tisza Eszlar conspiracy effectually prevented the anti-Semites from raising their voices with any effect again.

Meanwhile a more formidable and complicated outburst was preparing in Austria itself. Here the lines of the German agitation were closely followed, but with far more dramatic results. It was exclusively political—that is to say, it appealed to anti-Jewish prejudices for party purposes while it sought to rehabilitate them on a pseudo-scientific, racial, and economic basis. At first it was confined to sporadic pamphleteers. By their side there gradually grew up a school of Christian Socialists, recruited from the ultra-clericals, for the study and application of the doctrines preached at Mayence by Archbishop Ketteler. This constituted a complete Austrian analogue to the Evangelical-Socialist movement started in Germany by Herr Stoecker. For some years the two movements remained distinct, but signs of approximation were early visible. Thus one of the first complaints of the anti-Semites was that the Jews were becoming masters of the soil. This found an echo in the agrarian principles of the Christian Socialists, as expounded by Rudolph Meyer, in which individualism in landed property was admitted on the condition that the land-owners were "the families of the nation" and not "cosmopolitan financiers." A further indication of anti-Semitism is found in a speech delivered in 1878 by Prince Alois von Liechtenstein (b. 1846), the most prominent disciple of Rudolph Meyer, who denounced the national debt as a tribute paid by the state to cosmopolitan *rentiers* (Nitti, *Catholic Socialism*, pp. 200, 201, 211, 216). The growing disorder in parliament, due to the bitter struggle between the German and Czech parties, served to bring anti-Semitism into the field of practical politics. Since 1867 the German Liberals had been in power. They had made enemies of the clericals by tampering with the concordat, and they had split up their own party by the federalist policy adopted by Count Taaffe. The Radical secessionists in their turn found it difficult to agree, and an ultra-national German wing formed itself into a separate party under the leadership of Ritter von Schönerer (b. 1842), a Radical nationalist of the most violent type. In 1882 two anti-Semitic leagues had been founded in Vienna, and to these the Radical nationalists now appealed for support. The growing importance of the party led the premier, Count Taaffe, to angle for the support of the clericals by accepting a portion of the Christian Socialist programme. The higher episcopate, who felt assured that any permanent encouragement given to the anti-Semites would strengthen the parties of sedition and disorder in the end. Cardinal Schoenborn was despatched in haste to Rome to expostulate with the pontiff, and his representations were strongly supported by the French and Belgian bishops. The mischief was, however, done, and although the pope sent a verbal message to Prince Liechtenstein excluding the anti-Semites from his blessing, the elections resulted in a great triumph for the Jew-haters. The municipal council was immediately dissolved by the Government, and new elections were ordered, but these only strengthened the position of the anti-Semites, who carried 92 seats out of a total of 138. A cabinet crisis followed and the premiership was entrusted to the Statthalter of Galicia, Count Badeni, who assumed office with a pledge of war to the knife against anti-Semitism. In October the new municipal council elected as burgomaster of Vienna Dr Karl Lueger (b. 1844), a vehement anti-Semite, who had displaced Prince Liechtenstein as leader of the party. The emperor declined to sanction the election, but the council repeated it in face of the imperial displeasure. Once more a dissolution was ordered and for three months the city was governed by administrative commissioners. In February 1896 elections were again held and the anti-Semites were returned with an increased majority. The emperor then capitulated; and after a temporary arrangement, by which for one year Dr Lueger acted as vice-burgomaster and handed over the burgomastership to an inoffensive nominee, permitted the municipal council to have its way. The growing anarchy in parliament at this moment served still further to strengthen the anti-Semites, and their conquest of Vienna was speedily followed by a not less striking conquest of the landtag of Lower Austria (November 1896). The zenith of their power was reached in March 1897, when, at the general election for the Reichsrath, twenty-eight anti-Semites and forty-one German clericals were elected.

Since then a reaction of sanity has gradually but surely asserted itself. For five years the anti-Semites have (1901) governed Vienna, and, although they have accomplished much mischief, the millennium of which they were supposed to be the heralds has not dawned. On the contrary, the commercial interests of the city have suffered and the rates have been enormously increased (*Neue Freie Presse*, 29th March 1901), while the predatory hopes which secured them office have only been realized on a small and select scale. The spectacle of a clerico-anti-Semitic Tammany in Vienna has strengthened the resistance of the better elements in the country. Time has also shown that Christian Socialism is only a disguise for high Toryism, and that the German Radicals who were originally induced to join the anti-Semites have been victimized by the clericals. The fruits of this disillusion began to show themselves in the general elections of 1900-01, when the anti-Semites lost six seats in the Reichsrath and the clericals four, while the national German Radicals, rallied again into an independent and anti-clerical party under Ritter von Schönerer, gained thirteen seats. Three of the constituencies lost to the anti-Semites were in Vienna, and the total poll in their favour all over the city showed an enormous reduction. The elections were followed (26th January 1901) by a papal encyclical on Christian democracy, in which Christian Socialism was declared to be a term unacceptable to the Church, and the faithful were adjured to abstain from agitation of a demagogic and revolutionary character, and "to respect the rights of others."

The last country in Europe to make use of the teachings of German anti-Semitism in its party politics was France. The fact that the movement should have struck root in a republican country, where the ideals of democratic freedom have been so passionately cultivated, has been regarded as one of the paradoxes of our latter-day history. As a matter of fact, it is more surprising that it was not adopted earlier. All the social and political conditions which produced anti-Semitism in Germany were present in France, but in an aggravated form due primarily to the very republican *régime* which at first sight seemed to be a guarantee against it. In the monarchical states the dominance of the bourgeoisie was tempered in a measure by the power of the Crown and the political activity of the aristocracy, which carried with them a very real restraining influence in the matter of political honour and morality. In France these restraining influences were driven out of public life by the republic. The nobility both of the *ancien régime* and the empire stood aloof, and politics were abandoned for the most part to professional adventurers, while the bourgeoisie assumed the form of an omnipotent plutocracy. This naturally attracted to France all the financial adventurers in Europe, and in the train of the immigration came not a few German Jews, alienated from their own country by the agitation of Marr and Stoecker. Thus the bourgeoisie was not only more powerful in France than in other countries, but the obnoxiousness of its Jewish element was accentuated by a tinge of the national enemy. The anti-clericalism of the bourgeois republic and its unexampled series of financial scandals, culminating in the Panama *Krach*, thus sufficed to give anti-Semitism a strong hold on the public mind.

France.

Nevertheless, it was not until 1882 that the anti-Jewish movement was seriously heard of in France. M. Paul Bontoux (b. 1820), who had formerly been in the employ of the Rothschilds, but had been obliged to leave the firm in consequence of his disastrous speculations, had joined the Legitimist party, and had started the Union Générale with funds obtained from his new allies. M. Bontoux promised to break up the alleged financial monopoly of the Jews and Protestants and to found a new plutocracy in its stead, which should be mainly Roman Catholic and aristocratic. The bait was eagerly swallowed. For five years the Union Générale, with the blessing of the pope, pursued an apparently prosperous career. Immense schemes were undertaken, and the 125 fr. shares rose gradually to 3200 francs. The whole structure, however, rested on a basis of audacious speculation, and in January 1882 the Union Générale failed, with liabilities amounting to 212,000,000 francs. The cry was at once raised that the *Krach* was due to the manœuvres of the Jews, and a strong anti-Semitic feeling manifested itself in clerical and aristocratic circles. In 1886 violent expression was given to this feeling in a book since become famous, *La France Juive*, by M. Edouard Drumont (b. 1844). The author illustrated the theories of German anti-Semitism with a *chronique scandaleuse* full of piquant personalities, in which the corruption of French national life under Jewish influences was painted in alarming colours. The book was read with avidity by the public, who welcomed its explanations of the obviously growing debauchery. The Wilson scandals and the suspension of the Panama Company in the following year, while not bearing out M. Drumont's anti-Semitism, fully justified his view of the prevailing corruption. Out of this condition of things rose the Boulangist movement, which rallied all the disaffected elements in the country, including M. Drumont's following of anti-Semites. It was not, however, until the flight of General Boulanger and the ruin of his party that anti-Semitism came forward as a political movement.

The chief author of the rout of Boulangism was a Jewish politician and journalist, M. Joseph Reinach (b. 1856), formerly private secretary to M. Gambetta, and one of the ablest men in France. He was a Frenchman by birth and education, but his father and uncles were Germans, who had founded an important banking establishment in Paris. Hence he was held to personify the alien Jewish domination in France, and the ex-Boulangists turned against him and his co-religionists with fury. The Boulangist agitation had for a second time involved the Legitimists in heavy pecuniary losses, and under the leadership of the marquis de Morès they now threw all their influence on the side of M. Drumont. An anti-Semitic league was established, and with Royalist assistance branches were organized all over the country. The Franco-Russian alliance in 1891, when the persecutions of the Jews by M. Pobyedonostzeff were attracting the attention of Europe, served to invest M. Drumont's agitation with a fashionable and patriotic character. It was a sign of the spiritual approximation of the two peoples. In 1892 M. Drumont founded a daily anti-Semitic newspaper, *La Libre Parole*. With the organization of this journal a regular campaign for the discovery of scandals was instituted. At the same time a body of aristocratic swashbucklers, with the marquis de Morès and the count de Lamase at their head, set themselves to terrorize the Jews and provoke them to duels. At a meeting held at Neuilly in 1891 M. Guérin, one of the marquis de Morès's lieutenants, had demanded rhetorically *un cadavre de Juif*. He had not long to wait. Anti-Semitism was most powerful in the army, which was the only branch of the public service in which the reactionary classes were fully represented. The republican law compelling the seminarists to serve their term in the army had strengthened its clerical and Royalist elements, and the result was a movement against the Jewish officers, of whom 500 held commissions. A series of articles in the *Libre Parole* attacking these officers led to a number of ferocious duels, and these culminated in 1892 in the death of an amiable and popular Jewish officer, Captain Armand Mayer, of the Engineers, who fell, pierced through the lungs by the marquis de Morès. This tragedy, rendered all the more painful by the discovery that Captain Mayer had chivalrously fought to shield a friend, aroused a great deal of popular indignation against the anti-Semites, and for a moment it was believed that the agitation had been killed with its victim.

Towards the end of 1892, the discovery of the widespread corruption practised by the Panama Company gave a fresh impulse to anti-Semitism. The revelations were in a large measure due to the industry of the *Libre Parole*; and they were all the more welcome to the readers of that journal since it was discovered that three Jews were implicated in the scandals, one of whom, baron de Reinach, was uncle and father-in-law to the hated destroyer of Boulangism. The escape of the other two, Dr Herz and M. Arton, and the difficulties experienced in obtaining their extradition, deepened the popular conviction that the authorities were implicated in the scandals, and kept the public eye for a long time absorbed by the otherwise restricted Jewish aspects of the scandals. In 1894 the military side of the agitation was revived by the arrest of a prominent Jewish staff officer, Captain Alfred Dreyfus, on a charge of treason. From the beginning the hand of the anti-Semite was flagrant in the new sensation. The first hint of the arrest appeared in the *Libre Parole*; and before the facts had been officially communicated to the public that journal was busy with a campaign against the war minister, based on the apprehension that, in conspiracy with the *Juiverie* and his republican colleagues, he might exert himself to shield the traitor. Anti-Semitic feeling was now thoroughly aroused. Panama had prepared the people to believe anything; and when it was announced that a court-martial, sitting in secret, had convicted Dreyfus, there was a howl of execration against the Jews from one end of the country to the other, although the alleged crime of the convict and the evidence by which it was supported were quite unknown. Dreyfus was degraded and transported for life amid unparalleled scenes of public excitement.

The Dreyfus Case registers the climax not only of French, but of European anti-Semitism. It was the most ambitious and most unscrupulous attempt yet made to prove the nationalist hypothesis of the anti-Semites, and in its failure it afforded the most striking illustration of the dangers of the whole movement by bringing France to the verge of revolution. For a few months after the Dreyfus court-martial there was a comparative lull; but the highly-strung condition of popular passion was illustrated by a violent debate on "The Jewish Peril" in the Chamber of Deputies (25th April 1895), and by two outrages with explosives at the Rothschild Bank in Paris. Meanwhile the family of Dreyfus, absolutely convinced of his innocence, were casting about for the means of clearing his character and securing his liberation. They were wealthy, and their activity unsettled the public mind and aroused the apprehensions of the conspirators. Had the latter known how to preserve silence, the mystery would perhaps have been yet unsolved; but in their anxiety to allay all suspicions they made one false step, which proved the beginning of their ruin. Through their friends in the press they secured the publication of a facsimile of a document known as the *Bordereau*—a letter supposed to be in Dreyfus's handwriting and addressed apparently to the military attaché of a foreign power, which was alleged to constitute the chief evidence against the convict. It was hoped by this publication to put an end to the doubts of the so-called Dreyfusards. The result, however, was only to give them a clue on which they worked with remarkable ingenuity. To prove that the *Bordereau* was not in Dreyfus's handwriting was not difficult. Indeed, its authorship was recognized almost on the day of publication; but the Dreyfusards held their hands in order to make assurance doubly sure by further evidence. Meanwhile one of the officers of the general staff, Colonel Picquart, had convinced himself by an examination of the *dossier* of the trial that a gross miscarriage of justice had taken place. On mentioning his doubts to his superiors, who were animated partly by anti-Semitic feeling and partly by reluctance to confess to a mistake, he was ordered to the Tunisian hinterland on a dangerous expedition. Before leaving Paris, however, he took the precaution to confide his discovery to his legal adviser. Harassed by their anxieties, the conspirators made further communications to the newspapers; and the Government, questioned and badgered in parliament, added to the revelations. The new disclosures, so far from stopping the Dreyfusards, proved to them, among other things, that the conviction had been partially based on documents which had not been communicated to the counsel for the defence, and hence that the judges had been tampered with by the Ministry of War behind the prisoner's back. So far, too, as these documents related to correspondence with foreign military attachés, it was soon ascertained that they were forgeries. In this way a terrible indictment was gradually drawn up against the Ministry of War. The first step was taken towards the end of 1897 by a brother of Captain Dreyfus, who, in a letter to the minister of war, denounced Major Esterhazy as the real author of the *Bordereau*. The authorities, supported by parliament, declined to re-open the Dreyfus Case, but they ordered a court-martial on Esterhazy, which was held with closed doors and resulted in his acquittal. It now became clear that nothing short of an appeal to public opinion and a full exposure of all the iniquities that had been perpetrated would secure justice at the hands of the military chiefs. On behalf of Dreyfus, M. Zola, the eminent novelist, formulated the case against the general staff of the army in an open letter to the president of the republic, which by its dramatic accusations startled the whole world. The letter was denounced as wild and fantastic even by those who were in favour of revision. M. Zola was prosecuted for libel and convicted, and had to fly the country; but the agitation he had started was taken in hand by others, notably M. Clemenceau, M. Reinach, and M. Yves Guyot. In August 1898 their efforts found their first reward. A re-examination of the documents in the case by M. Cavaignac, then minister of war, showed that one was undoubtedly forged. Colonel Henry, of the Intelligence Department of the War Office, then confessed that he had fabricated the document, and, on being sent to Mont Valérien under arrest, cut his throat.

In spite of this damaging discovery the War Office still persisted in believing Dreyfus guilty, and opposed a fresh inquiry. It was supported by three successive ministers of war, and apparently an overwhelming body of public opinion. By this time the question of the guilt or innocence of Dreyfus had become an altogether subsidiary issue. As in Germany and Austria, the anti-Semitic crusade had passed into the hands of the political parties. On the one hand the Radicals and Socialists, recognizing the anti-republican aims of the agitators and alarmed by the clerical predominance in the army, had thrown in their lot with the Dreyfusards; on the other the reactionaries, anxious to secure the support of the army, took the opposite view, denounced their opponents as *sans patrie*, and declared that they were conspiring to weaken and degrade the army in the face of the national enemy. The controversy was, consequently, no longer for or against Dreyfus, but for or against the army, and behind it was a life-or-death struggle between the republic and its enemies. The situation became alarming. Rumours of military plots filled the air. Powerful leagues for working up public feeling were formed and organized; attempts to discredit the republic and intimidate the Government were made. The president was insulted; there were tumults in the streets, and an attempt was made by M. Déroulède to induce the military to march on the Elysée and upset the republic. In this critical situation France, to her eternal honour, found men with sufficient courage to do the right. The Socialists, by rallying to the Radicals against the reactionaries, secured a majority for the defence of the republic in parliament. M. Brisson's Cabinet transmitted to the Court of Cassation an application for the revision of the case against Dreyfus; and that tribunal, after an elaborate inquiry, which fully justified M. Zola's famous letter, quashed and annulled the proceedings of the court-martial, and remitted the accused to another court-martial, to be held at Rennes. Throughout these proceedings the military party fought tooth and nail to impede the course of justice; and although the innocence of Dreyfus had been completely established, it concentrated all its efforts to secure a fresh condemnation of the prisoner at Rennes. Popular passion was at fever heat, and it manifested itself in an attack on M. Labori, one of the counsel for the defence, who was shot and wounded on the eve of his cross-examination of the witnesses for the prosecution. To the amazement and indignation of the whole world outside France, the Rennes court-martial again found the prisoner guilty; but all reliance on the conscientiousness of the verdict was removed by a rider, which found "extenuating circumstances," and by a reduction of the punishment to ten years' imprisonment, to which was added a recommendation to mercy. The verdict was evidently an attempt at a compromise, and the Government resolved to advise the president of the republic to pardon Dreyfus. This lame conclusion did not satisfy the accused; but his innocence had been so clearly proved, and on political grounds there were such urgent reasons for desiring a termination of the affair, that it was accepted without protest by the majority of moderate men. The explanation of the whole case is that Esterhazy and Henry were the real culprits; that they had made a trade of supplying the German Government with military documents; and that, when the *Bordereau* was discovered, they availed themselves of the anti-Semitic agitation to throw suspicion on Dreyfus.

The rehabilitation of Dreyfus did not pass without another effort on the part of the reactionaries to turn the popular passions excited by the case to their own advantage. After the failure of M. Déroulède's attempt to overturn the republic, the various Royalist and Boulangist leagues, with the assistance of the anti-Semites, organized another plot. This was discovered by the Government, and the leaders were arrested. M. Jules Guérin, secretary of the anti-Semitic league, shut himself up in the league offices in the Rue Chabrol, Paris, which had been fortified and garrisoned by a number of his friends, armed with rifles. For more than a month the anti-Semites held the authorities at bay, and some 5000 troops were employed in the siege. The conspirators were all tried by the Senate, sitting as a high court, and M. Guérin was sentenced to ten years' imprisonment. The evidence showed that the anti-Semitic organization had taken an active part in the anti-republican plot (see the report of the Commission d'Instruction in the *Petit Temps*, 1st November 1899). This vigorous action of the Government, together with the moral effect of the Dreyfus Case, has seriously weakened the anti-Semitic movement in France, and it has now completely lost its hold on the public outside Paris.

In sympathy with the agitation in France there has been a similar movement in Algeria, where the European population have long resented the admission of the native Jews to the rights of French citizenship. The agitation has been marked by much violence, and most of the anti-Semitic deputies in the French parliament, including M. Drumont, have found constituencies in Algeria. As the local anti-Semites are largely Spaniards and Levantine riff-raff, the agitation has not the peculiar nationalist bias which characterizes Continental anti-Semitism. Before the energy of the authorities it has lately shown signs of subsiding.

Great Britain, etc.

While the main activity of anti-Semitism has manifested itself in Germany, Russia, Rumania, Austria-Hungary, and France, its vibratory influences have been felt in other countries when conditions favourable to its extension have presented themselves. In England more than one attempt to acclimatize the doctrines of Marr and Treitschke has been made. The circumstance that at the time of the rise of German anti-Semitism a premier of Hebrew race, Lord Beaconsfield, was in power first suggested the Jewish bogey to English political extremists. The Eastern Crisis of 1876-78, which was regarded by the Liberal party as primarily a struggle between Christianity, as represented by Russia, and a degrading Semitism, as represented by Turkey, accentuated the anti-Jewish feeling, owing to the anti-Russian attitude adopted by the Government. Violent expression to the ancient prejudices against the Jews was given by Sir J. G. Tollemache Sinclair (*A Defence of Russia*, 1877). Mr T. P. O'Connor, in a life of Lord Beaconsfield (1878), pictured him as the instrument of the Jewish people, "moulding the whole policy of Christendom to Jewish aims." Professor Goldwin Smith, in several articles in the *Nineteenth Century* (1878, 1881, and 1882), sought to synthetize the growing anti-Jewish feeling by adopting the nationalist theories of the German anti-Semites. This movement did not fail to find an equivocal response in the speeches of some of the leading Liberal statesmen; but on the country generally it produced no effect. It was revived when the persecutions in Russia threatened England with a great influx of Polish Jews, whose mode of life was calculated to lower the standard of living in the industries in which they were employed. All danger was, however, averted by the Jewish communal authorities, who, by dint of great pecuniary sacrifices and an excellent international organization, managed to control the immigration. In 1883 Herr Stoecker visited London, but received a very unflattering reception. Equally abortive attempts to acclimatize anti-Semitism have been made in Switzerland, Belgium, Greece, and the United States.

Anti-Semitism has made a great deal of history during the last thirty years, but it has left no permanent mark on the social and political evolution of Europe. It is the fruit of a great ethnographic and political error, and it has spent itself in political intrigues of transparent dishonesty. Its racial doctrine is at best a crude hypothesis; its nationalist theory has only served to throw into striking relief the essentially economic bases of modern society, while its political activity has revealed the vulgarity and ignorance which constitute its main sources of strength. So far from injuring the Jews, it has really given Jewish racial separatism a new lease of life. Its extravagant accusations, as in the Tisza Eszlar and Dreyfus cases, have resulted in the vindication of the Jewish character. Its agitation generally, coinciding with the revival of interest in Jewish history, has helped to transfer Jewish solidarity from a religious to a racial basis. The bond of a common race, vitalized by a new pride in Hebrew history and spurred on to resistance by the insults of the anti-Semites, has given a new spirit and a new source of strength to Judaism at a moment when the approximation of ethical systems and the revolt against dogma were sapping its essentially religious foundations. In the whole history of Judaism, perhaps, there have been no more numerous or remarkable instances of reversions to the faith than during the last thirty years. The reply of the Jews to anti-Semitism has taken two interesting practical forms. In the first place there is the so-called Zionist movement, which is a kind of Jewish nationalism and is vitiated by the same errors that distinguish its anti-Semitic analogue. It aims at the re-establishment of the Jewish state; and, under the leadership of Dr Theodor Herzl (b. 1860) and Dr Max Nordau (b. 1849) it has found no fewer than a quarter of a million supporters, who are now definitely organized. In the second place, there is a movement represented by the Maccabaeans' Society in London, which seeks to unite the Jewish people in an effort to raise the Jewish character and to promote a higher consciousness of the dignity of the race. It lays no stress on orthodoxy, but welcomes all who strive to render Jewish conduct an adequate reply to the theories of the anti-Semites. Both these movements are elements of fresh vitality to Judaism, and they are probably destined to produce important fruit in the near future. A splendid spirit of generosity has also been displayed by the Jewish community in assisting and relieving the victims of the Jew-haters. Besides countless funds raised by public subscription, Baron de Hirsch founded a colossal scheme for transplanting persecuted Jews to new countries under new conditions of life, and endowed it with no less a sum than £9,000,000 (see HIRSCH, MORITZ DE).

Though anti-Semitism has been unmasked and discredited, it is to be feared that its history is not yet at an end. While there are in Russia and Rumania six millions of Jews who are being systematically degraded, and who periodically overflow the western frontier, there will continue to be a Jewish question in Europe; and while there are weak Governments, as in Austria and France, and ignorant and superstitious elements in the enfranchized classes of those countries, that question will seek to play a part in politics.

LITERATURE.—No impartial history of modern anti-Semitism has yet been written. The most comprehensive works on the subject, *Israel among the Nations*, by A. LEROY-BEAULIEU (1895), and *L'Antisémitisme, son Histoire et ses causes*, by BERNARD LAZARE (1894), are collections of studies rather than histories. M. Lazare's work will be found most useful by the student on account of its detached standpoint and its valuable bibliographical notes. A good list of works relating to Jewish ethnography will be found at the end of M. Isidore Loeb's valuable article, "Juifs," in the *Dictionnaire Universel de Géographie* (1884). To these should be added JELLINEK, *Der Jüdische Stamm* (1869); CHWOLSON, *Die Semitischen Völker* (1872); NOSSIG, *Materialien zur Statistik* (1887); JACOBS, *Jewish Statistics* (1891); and ANDRÉE, *Zur Volkskunde der Juden* (1881). A bibliography of the Jewish question from 1875 to 1884 has been published by Mr Joseph Jacobs (1885). Useful additions and rectifications will be found in the *Jewish World*, 11th September 1885. During the last fifteen years the anti-Semitic movement has produced an immense pamphlet literature. Some of these productions have already been referred to; others will be found in current bibliographies under the names of the personages mentioned, such as Stoecker, Ahlwardt, &c. On the Russian persecutions, besides the works quoted by Jacobs, see the pamphlet issued by the Russo-Jewish Committee in 1890, and the annual reports of the Russo-Jewish Mansion House Fund; *Les Juifs de Russie* (Paris, 1891); *Report of the Commissioners of Immigration upon the Causes which incite Immigration to the United States* (Washington, 1892); *The New Exodus*, by HAROLD FREDERIC (1892); *Les Juifs Russes*, by LEO ERRERA (Brussels, 1893). The most valuable collection of facts relating to the persecutions of 1881-82 are to be found in the *Feuilles Jaunes* (52 nos.), compiled and circulated for the information of the European press by the Alliance Israélite of Paris. Complete collections are very scarce. On the Rumanian question, see BLUNTSCHLI, *Roumania and the Legal Status of the Jews* (London, 1879); *Wir Juden* (Zurich, 1883); SCHLOSS, *The Persecution of the Jews in Roumania* (London, 1885); SCHLOSS, *Notes of Information* (1886); SINCERUS, *Juifs en Roumanie* (London, 1901); PLOTKE, *Die Rumänischen Juden unter dem Fürsten u. König Karl* (1901); DEHN, *Diplomatie u. Hochfinanz in der Rumanischen Judenfrage* (1901); CONYBEARE, *Roumania as a Persecuting Power* (*Nat. Rev.* February 1901). On Hungary and the Tisza Eszlar Case, see, besides the references in Jacobs, NATHAN, *Der Process von Tisza Eszlar* (Berlin, 1892). On this case and the Blood Accusation generally, see WRIGHT, "The Jews and the Malicious Charge of Human Sacrifice" (*Nineteenth Century*, 1883). The origins of the Austrian agitation are dealt with by NITTI, *Catholic Socialism* (1895). This work, though inclining to anti-Semitism, should be consulted for the Christian Socialist elements in the whole Continental agitation. The most valuable source of information on the Austrian movement is the *Oesterreichische Wochenschrift*, edited by Dr BLOCH. See also pamphlets and speeches by the anti-Semitic leaders, LIECHTENSTEIN, LUEGER, SCHOENERER, &c. The case of the French anti-Semites is stated by E. DRUMONT in his *France Juive*, and other works; the other side by Isidor Loeb, Bernard Lazare, Leonce Reynaud, &c. Of the Dreyfus Case there is an enormous literature, see especially the reports of the Zola and Picquart trials, the revision case before the Court of Cassation, and the proceedings of the Rennes court-martial; also the valuable series of volumes by Captain Paul Marin, MM. Clemenceau, Reinach, Lazare, Yves Guyot, Paschal Grousset, Urbain Gohier, De Haime, De Pressensé, and the remarkable letters of DREYFUS (*Lettres d'un innocent*). An English history of the case has been published by Mr Conybeare, whose articles and those of Sir Godfrey Lushington and Mr Maxse in the *National Review*, 1897-1900, will be found invaluable by the student. On the Algerian question, see M. WAHL in the *Revue des Études Juives*; L. FOREST, *Naturalisation des Israélites Algériens*; and E. AUDINET in the *Revue Generale de Droit International Publique*, 1897, No. 4. A good summary of the aims and literature of Zionism will be found in the *Nineteenth Century*, August 1897. On the history of the anti-Semitic movement generally, see the annual reports of the Alliance Israélite of Paris and the Anglo-Jewish Association of London, also the annual summaries published at the end of the Jewish year by the *Jewish Chronicle* of London. The connexion of the movement with general party politics must be followed in the newspapers. The present writer has worked with a collection of newspaper cuttings numbering several thousands and ranging over twenty years. A skeleton guide may be obtained by a careful study of SEIGNOBOS, *Histoire Politique de l'Europe Contemporaine* (1897), aided by *Hazell's Annual*, and SCHULTHESS, *Europaischer Geschichtskalender*. (L. W.)

Antitoxin. See BACTERIOLOGY, II.

Antivari, or BAR, so called from its position opposite Bari in Italy, once a town of Turkish Albania, now Montenegrin, situated near the Adriatic Sea, 18 miles N.W. of Scutari, and surrounded by a dense forest of olive trees. Its old Venetian castle suffered greatly from the siege by the Montenegrins in 1878, and is now in ruins. There is a good harbour (Pristan) for vessels of light draught, and a beautiful residence for the prince one hour distant from the town, which had at one time a considerable trade in the products of Albania, but is now of little importance. It is the seat of a Roman Catholic archbishop. Population, about 1500, mostly Albanians.

Antofagasta, a town and port on the Pacific and the capital of the Chilian province and department of the same name, situated in 23° 38′ 39″ S. lat. and 70° 24′ 39″ W. long., about 768 miles N. of Valparaiso. It belonged to Bolivia until occupied in 1879 by Chile, then at war with the former country; its occupation was agreed to by Peru in 1884, and it was definitely ceded to Chile by the treaty of 1885. The population in 1895 was 13,530; in 1898 it was estimated at 16,795. It is the head of the railway to Oruro in Bolivia, and most of the Bolivian export trade passes through it. The total value of the exports in 1897 was (Chilian currency) $4,237,811; of the imports, $2,187,171. In the same year the shipping which entered had a tonnage of 75,224 tons. The value of the Bolivian mineral products exported through it in 1898 was $29,994,914 (Chilian currency). The province of ANTOFAGASTA has an area of 47,918 square miles, and had in 1895 a population of 44,085. It is divided into three departments. In 1898 the marriages numbered 253, the births 1561, and the deaths 1093.

Antonelli, Giacomo (1806-1876), Italian Cardinal, was born at Sonnino, 2nd April 1806. He was educated for the priesthood, but, after taking orders, preferred an administrative career. Created secular prelate, he was sent as apostolic delegate to Viterbo, where he early manifested his reactionary tendencies in an attempt to stamp out Liberalism. Recalled to Rome in 1841, he entered the office of the papal secretary of state, but four years later was appointed pontifical treasurer-general. Created cardinal (11th June 1847), he was chosen by Pius IX. to preside over the council of state entrusted with the drafting of the constitution. On 10th March 1848 Antonelli became premier of the first constitutional ministry of Pius IX., a capacity in which he displayed unscrupulous duplicity. Upon the fall of his cabinet Antonelli created for himself the governorship of the sacred palaces in order to retain constant access to and influence over the Pope. After the assassination of Pellegrino Rossi (15th November 1848) he arranged the flight of Pius IX. to Gaeta, where he was appointed secretary of state. Notwithstanding promises to the Powers, he restored absolute government upon returning to Rome (12th April 1850) and violated the conditions of the surrender by wholesale imprisonment of Liberals. In 1855 he narrowly escaped assassination. As ally of the Bourbons of Naples, from whom he had received an annual subsidy, he attempted, after 1860, to facilitate their restoration by fomenting brigandage on the Neapolitan frontier. To the overtures of Ricasoli in 1861, Pius IX., at Antonelli's suggestion, replied with the famous "*Non possumus,*" but subsequently (1867) accepted, too late, Ricasoli's proposal concerning ecclesiastical property. After the September Convention (1864) Antonelli organized the Legion of Antibes to replace French troops in Rome, and in 1867 secured French aid against Garibaldi's invasion of papal territory. Upon the reoccupation of Rome by the French after Mentana, Antonelli again ruled supreme, but upon the entry of the Italians in 1870 was obliged to restrict his activity to the management of foreign relations. He wrote, with papal approval, the letter requesting the Italians to occupy the Leonine city, and obtained from the Italians payment of the Peter's pence (5,000,000 lire) remaining in the papal exchequer, as well as 50,000 scudi—the first and only instalment of the Italian allowance ever accepted by the Holy See. At Antonelli's death in 1876 the Vatican finances were found to be in disorder, with a deficit of 45,000,000 lire. His personal fortune, accumulated during office, was considerable, and was bequeathed entirely to members of his family. From 1850 until his death he interfered little in affairs of dogma and church discipline, although he addressed to the Powers circulars enclosing the Syllabus (1864) and the acts of the Vatican Council (1870). His activity was devoted almost exclusively to the political aspects of the struggle between the papacy and the Italian Risorgimento. (H. W. S.)

Antrim, a maritime county of Ireland, province of Ulster, bounded on the N. and N.E. and E. by the North Channel, on the S. by Co. Down, on the S.W. by Lough Neagh, and on the W. by Co. Londonderry.

Population.—The area of the administrative county in 1899 was 711,487 acres, of which 225,926 were tillage, 358,080 pasture, 747 fallow, 6140 plantation, 24,170 turf bog, 6538 marsh, 51,896 barren mountain, and 37,990 water, roads, fences, &c. The new administrative county under the Local Government (Ireland) Act, 1898, includes the portion of the town of Lisburn formerly situated in Down, and the town of Carrickfergus, formerly a separate county, but does not include the portion of the city of Belfast formerly situated in Antrim. The population in 1881 was 421,943, and in 1891, 428,128, of whom 200,514 were males and 227,614 females, divided as follows among the different religions: Presbyterians, 180,375; Roman Catholics, 106,390; Protestant Episcopalians, 106,244; Methodists, 14,745; other denominations, 20,162. The increase of population between 1881 and 1891 was 1·47 per cent., the largest percentage of increase in Ireland. The average number of persons to an acre was ·56. Of the total population 176,923 inhabited the rural districts, being an average of 205 persons to each square mile under crops and pasture. In 1901 the population was 461,240, showing an increase of 7 per cent.

Education.—The following table gives the degree of education in 1891 (excluding Belfast and Carrickfergus):—

	Males.	Females.	Total.	Percentage.		
				R.C.	Pr. Epis.	Presb.
Read and write	68,437	70,920	139,357	64·6	71·8	80·5
Read only . .	10,736	16,806	27,542	17·3	16·8	13·8
Illiterate . .	8202	9322	17,524	18·1	11·4	5·7

In 1881 the percentage of illiterates among Roman Catholics was 24·0. In 1891 in the whole county there were 53 superior schools with 3470 pupils (613 Roman Catholics and 2857 Protestants), and 735 primary schools with 67,446 pupils (15,419 Roman Catholics and 52,027 Protestants). The number of pupils on the rolls of the national schools on 30th September 1899 was 80,943, of whom 18,200 were Roman Catholics and 62,743 Protestants.

The following table gives the number of births, deaths, and marriages in various years:—

Year.	Births.	Deaths.	Marriages.
1881	12,869	8184	2631
1891	12,459	9586	3255
1899	13,374	9982	3582

In 1899 the birth-rate per 1000 was 31·0, and the death-rate 23·2; the rate of illegitimacy was 4·3 per cent. of the total births. The total number of emigrants who left the county between 1st May 1851 and 31st December 1899 was 249,354, of whom 144,588 were males and 104,766 females. The chief towns in the county are Belfast, 348,965; Lisburn, 11,459; Carrickfergus, and Ballymena.

Administration.—The county is divided into four parliamentary divisions—north, mid, east, and south; the number of registered electors in 1900 being respectively 8600, 8219, 8886, and 10,381. The rateable valuation in 1900 was £693,685, the county borough of Belfast being now rated separately. By the Local Government (Ireland) Act, 1898, the fiscal and administrative duties of the grand jury (and to a less extent) of other bodies were transferred to a county council, urban and rural district councils were established, and under that Act the county now comprises six urban and eight rural sanitary districts. The same Act abolished the separate county of the town of Carrickfergus and constituted the city of Belfast a separate county.

Agriculture.—The following tables show the acreage under crops, including meadow and clover, and the amount of live stock in 1881, 1891, 1895, and 1899. The figures for 1899 are for the new administrative county:—

	Wheat.	Oats.	Barley, Beans, etc.	Potatoes.	Turnips.	Other green Crops.	Flax.	Meadow and Clover.	Total.
1881	4442	76,445	3692	46,027	9,471	3044	17,662	87,347	248,330
1891	1957	67,540	2390	41,508	10,402	1962	15,010	90,163	231,022
1895	741	67,358	1509	40,251	11,419	1518	15,373	98,021	236,281
1899	1350	66,020	1711	37,408	12,148	2223	8,012	96,255	225,926

In 1899 the total value of the cereal and other crops was estimated by the Registrar-General at £1,768,536. The number of acres under pasture in 1881 was 340,120; in 1891, 345,554; and in 1899, 358,080.

	Horses and Mules.	Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.
1881	29,743	576	138,510	56,849	46,821	5074	450,180
1891	32,147	670	157,550	122,423	65,835	6859	573,384
1895	34,376	687	158,662	98,226	61,205	5392	600,865
1899	33,512	752	156,338	100,345	60,860	5825	714,595

The number of milch cows in 1891 was 64,365, and in 1899, 64,875. It is estimated that the total value of cattle, sheep, and pigs in 1899 was £2,305,016.

In 1899 the number of holdings not exceeding 1 acre was 2678; between 1 and 5, 2000; between 5 and 15, 5346; between 15 and 30, 5992; between 30 and 50, 3646; between 50 and 100, 2374; between 100 and 200, 556; between 200 and 500, 155; and above 500, 46—total, 22,793. The total number of loans issued (the number of tenants being the same as the number of loans) under the Land Purchase Acts, 1885, 1891, 1896, up to 31st March 1900, was 3521, amounting to £1,134,873. The number of loans sanctioned for agricultural improvements under sect. 31 of the Land Act, 1881, between 1882 and 1900 was 132, and the amount issued was £11,415. The total amount issued for all classes of works under the Land Improvement Acts from the commencement of operations in 1847 to 31st March 1900 was £138,203.

Minerals.—The following were the outputs of the various mines in 1899,—coal, 6111 tons, iron ore, 102,262 tons, value £16,015; rock salt, 47,055 tons, value £13,319; and alum clay, 8099 tons, value £1871. The output of iron ore has been almost continually increasing, and the production of alumina from alum clay forms a new branch of industry. The alumina is prepared at works near Larne; 1500 tons, value £28,000, having been extracted in 1899.

Fisheries.—In 1899, 231 vessels, employing 476 hands, were registered in the deep sea and coast fishing districts of Ballycastle and Carrickfergus. 212 persons were employed in the salmon fishing district of Ballycastle in the same year.

Antrim, a town in the above county, on the Six-mile Water, 13 miles N.W. of Belfast by rail, on the Great Northern Railway. It is governed by town commissioners, but, under the Local Government (Ireland) Act, 1898, can apply to be constituted an urban sanitary district. Area, 198 acres. Population (1891), 1385; (1901), 1825.

Antwerp (French *Anvers*), a city, port, and stronghold of Belgium, capital of the province of the same name, on the right bank of the Scheldt, about 50 miles from the sea and 25 N. of Brussels by rail. The wall which, since the old fortifications were demolished in 1860, has shut in the city wherever unprotected by the river, encloses the suburbs of Borgerhout and Berchem, and measures over 8½ miles; seventeen gates give entrance to the city, and twelve forts serve for the defence. The city has spread rapidly within recent years; a new quarter has sprung up all along the line of the old fortifications, containing many handsome erections such as the new Art Gallery, the Law Courts, the National Bank, the National Theatre, and the Athenæum. But it is the commercial importance of Antwerp which above all else distinguishes the city. In this direction the dock accommodation is still insufficient for the vast and still growing trade, though considerable extensions have been carried out, and the quays now stretch along the Scheldt for 2½ miles. These are backed by large warehouses, on the top of which a fine promenade has been constructed, and behind these again open out thirteen basins of various sizes. Sixty shipping lines have their headquarters at Antwerp, and in conjunction with numerous other lines which make it a port of call place the city in communication with every part of the world. In 1880, 4495 vessels (2292 British) of 3,063,825 tons entered the port; in 1899, 5613 (3013 British) of 6,872,848 tons. Imports were valued at £49,700,000 in 1880, and £65,027,600 in 1899; exports at £16,533,000 in 1880, and £32,615,000 in 1899. The principal imports are now, in order of importance, grain of all kinds, raw textile materials (wool, cotton, flax, &c.), mineral ores and metals, provisions, rice, animal products, and guano; the principal exports are glass-ware, wrought metal, railway carriages, cement, worsted and thread. Antwerp proper has nearly doubled its population within the last twenty-five years. In 1875 there were 148,800 inhabitants; in 1880, 169,100; in 1890, 224,000; and in 1899, 282,000. Including the two suburbs of Borgerhout and Berchem, the total population in 1899 was 338,800.

The province of ANTWERP (Fr. *Anvers*), Belgium, between the Netherlands on the N. and E., the province of Limbourg on the E., Brabant on the S., and East Flanders on the W., is formed of the ancient territories of the marquisate of Antwerp and the lordship of Malines and of a part of the ancient duchy of Brabant. The land spreads out flat and low. In large part Antwerp belongs to the sandy region known as the Campine. A canal from Antwerp to Maastricht joins the basin of the Scheldt to that of the Meuse. Besides its important commercial centre of Antwerp, the province carries on the industries of shipbuilding, paper-making, woollen textiles, and cement. It is divided into the three administrative arrondissements of Antwerp, Malines, and Turnhout. The province covers 1093 square miles, with a population in 1899 of 825,000 (or 753·7 to a square mile) against 531,750 in 1875. The arrondissement of Antwerp had a population in 1899 of 513,500, or 1367·5 per square mile.

See MERTENS ET TORFS. *Geschiedenis van Antwerpen.*—EUG. GENS. *Histoire de la ville d'Anvers.*—GÉNARD. *Anvers à travers les âges.*—*Rapport de la Chambre de Commerce d'Anvers*, 1898; and *Annuaire statistique de la Belgique*, 1899. (J. DE P.)

Anuradhapura, the chief town in the north-central province of Ceylon, and the ancient capital of the island for twelve centuries from 437 B.C. It is an extensive "buried city," now being gradually excavated under an archæological survey by the government of Ceylon. Its dagabas and other Buddhist ruins excite much interest. It can be visited by rail and coach in two days from Colombo; but the railway is about to be extended all the way. Population—town, 3000; province, 79,022.

Anzin, a town of France, department of Nord, in the arrondissement of Valenciennes, 1½ miles N.W. of that town, of which it is a suburb, on the railway from Somain to Péruwelz. Its metallurgical industries are very extensive, and include several large establishments engaged in the manufacture of steam engines, machinery, chain-cables, and a great variety of heavy iron goods. The number of puddling furnaces in operation in Anzin and Denain in 1899 was 25. The output of coal in the same year from the mines under the control of the Société d'Anzin was 2,973,000 tons, and the number of persons employed was 12,200. Population (1891), 11,394; (1896), 12,606; (comm.), 12,768.

Apamea, (1) a treasure-city, and stud-depot of the Seleucid kings in the valley of the Orontes. Destroyed by Chosroes in the 7th century A.D.; partially rebuilt and known as *Fámia* by the Arabs; end overthrown by an earthquake in 1152. The acropolis hill is now occupied by the ruins of Kalât el-Mudîk. (2) In Phrygia. Founded by Antiochus Soter, near, but on lower ground than, Celænæ. It was situated at the exit of the Marsyas from the hills, and became a seat of Seleucid power, and a centre of Greco-Roman civilization and commerce. For a long period it was one of the greatest cities of Asia Minor, but when the trade routes were diverted to Constantinople it rapidly declined, and its ruin was completed by an earthquake. An early Christian tradition, possibly arising from a name, *Cibotus* (ark), which the town bore, identified the neighbouring mountain with Ararat. The site is now partly occupied by Dineir, which is connected with Smyrna by railway, and there are extensive remains. (3) On the left bank of the Euphrates, at the end of a bridge of boats (*zeugma*). The Til-Barsip of the Assyrian inscriptions, now Birejik. (4) The earlier Myrlea of Bithynia, now Mudánia, the port of Brúsa.

HIRSCHFELD, "Über Celainai-Apameia-Kibotos," in *Transactions of Berlin Academy*, 1876.—HOGARTH, in *Journal of Hellenic Studies*, 1888.—RAMSAY, *Cities and Bishoprics of Phrygia*, vol. ii. Oxford.

Apeldoorn, a flourishing village in the Netherlands, in the province of Gelderland, 17 miles north of Arnhem. The Protestant church, burned down in 1890, has been restored, and an aqueduct built (1894) from the neighbouring hills. Population (1900), 25,761.

Apennines, the mountain backbone of Italy, some 800 miles long by 70 to 80 miles in maximum width. The central chain, or main axis, of the Apennines may perhaps be regarded as a flanking range of a primeval central mass now sunk beneath the Tyrrhenian Sea, and the Apuan Alps, a western outlier of the Northern Apennines, and the mountains of Calabria, which are the oldest parts of the system, being composed almost entirely of crystalline rocks, as surviving fragments of the same primeval Tyrrhenian mainland. Apart from the Apuan Alps, the Northern Apennines consist principally of older Tertiary formations and younger members of the Cretaceous epoch, chiefly sandstones and marly slates, broken through in many places by rounded protrusions of gabbro and serpentine. These serpentine outflows occur again in the "compartment" of Potenza (province, Basilicata) in the south, but do not appear in the Central Apennines. The Central Apennines may be briefly described as consisting of a series of vast ellipsoidal outcrops of the limestone core (Cretaceous to Triassic) of the system, thrust up above the broad base of younger formations, which flank it on east and west. South of the Esino valley and the Ancona-Spoleto railway there are two clearly marked continuing ranges, with parallel strikes, the western prolonging the Catria chain and the eastern culminating in Monte San Vicino. On the whole of the east side of the Sibilline Mountains, one of the principal constituents of the Central Apennines, there has been a gigantic subsidence, the face of the rupture showing a sheer vertical altitude of some 6500 ft. The culminating peaks of this constituent range reach an altitude of 8125 ft. in Monte de Pretara and 8010 ft. in Monte Vettore. There are snow-fields on various peaks of the Gran Sasso d'Italia, the next (going south) constituent chain of the Central Apennines, as on Monte Corno (above 8530 feet), on Pizzo Intermesole (above 8585 ft.), and on Monte Corvo (above 8550 ft.); and it is on the same chain, or rather mountain-knot, that the only glaciers, though in a rudimentary form, occur in the Apennines. They lie in the high valleys above the sources of the Arno, at altitudes of 5400 ft. and upwards, and in the valleys which feed the Venaquaro (*i.e.*, the Vomano), at eltitudes of 6400 ft. and above. It may be mentioned that the last surviving chamois on the Gran Sasso is believed to have been shot in 1880. Monte Amaro, the culminating peak of the Majella Mountains, the next constituent chain, reaches an altitude of 9170 ft. Except for small quantities of anthracite and sulphur, the Apennines contain no minerals, but possess several mineral springs, of which the best known are those at Lucca, Montecatini, San Casciano, Porretta, and Telese. In very many cases the valleys on the east of the Apennines differ from those on the west, in that they are not only shorter, but run transversely to the main axis of the system; whereas, on the west or Mediterranean side, they frequently lie parallel to the axis. The most notable examples of the latter are the upper valleys of the Arno and the Tiber. Above 3000 ft. the Apennines are in general bare and barren of vegetation, except for a little scrub and some scanty pasture in summer; but below that limit their slopes are as a rule the reverse, being well planted with vines, olives, chestnuts, orange, citron, and other fruit trees, besides yielding the usual crops. Of the Apennine lakes, Lake Fucino was drained and made amenable to cultivation in 1876, after more than twenty years' labour, and Lake Trasimeno was provided with a second outlet in 1896-98. The project of draining the latter, originally suggested by Napoleon I., has been repeatedly under consideration, but as yet has come to nothing. The lakes of Bolsena, Vico, Bracciano, and Albano lie west of the main chain, and are volcanic-crater lakes. The central ranges of the Apennines exercise, as might be expected, an important influence upon the local climatic conditions on both the Adriatic and Atlantic versants. One consequence of their position is that the extremes of temperature diminish as one descends towards the coast, as well as proceeds towards the south. On the Adriatic side, that is, in the provinces of Emilia (part), Umbria, the Marches, and the Abruzzi, the annual mean does not exceed 57° F., the January mean 38·1°, or the July mean 75·2°. The difference between the absolute maximum of 100·4° (at Forlì) and the absolute minimum of 5° (at Camerino) amounts to 95·4°. The higher parts, as represented by Urbino (1481 ft. above sea-level) and Camerino (2177 ft.), have naturally a lower annual mean (53°) than places near the coast, such as Forlì (163 ft.), Jesi (332 ft.), and Ancona (52 ft.), whose annual mean is 59·6°. On the Mediterranean side the annual mean is somewhat higher than the general mean of the Adriatic side, namely, 57·7° (Perugia, at 1706 ft., having a mean of 55·2°, and Leghorn, at 78 ft., 59·7°); but the January mean is appreciably higher, namely, 41·5°, though the July mean is practically the same, 75·4°. The range between the extremes—105·1° at Florence and 12·2° also at Florence—is also less, namely, 92·9°. Farther south, in Apulia, Basilicata, and Calabria, the annual mean is 58·1° (Potenza, 2711 ft., 50·2°; Lecce, 236 ft., 61·9°); the January mean, 42·9°; and the July mean, 75·1°. The extremes lie at 93·9° (Lecce), and 13·6° (Potenza). The heaviest rainfall occurs as a rule in the higher mountainous parts; for instance, at Urbino, an average of 39½ inches falls annually (period of observations, 43 years); at Camerino, 38½ in. (47 years); at Siena, 30½ in. (55 years); at Florence, 34½ in. (65 years); and at Cosenza, 42 in. (19 years). But to this there are some exceptions; for instance, at Aquila, under the shelter of the Gran Sasso, the annual average is only

25½ in. (20 years); and at Potenza, in the valley of the Basento, it is 24 in. (15 years). On the west side of the peninsula the rainfall is relatively heavier than on the east: at Rome, 30½ in. (69 years); and Naples, 32 in. (73 years); as compared with 26½ in. at Ancona (30 years), and 23 in. at Lecce (19 years). The main chain of the Apennines is now crossed or pierced by a dozen railway lines, *e.g.*, by the line from Genoa to Alessandria, Savona to Turin, Spezia to Parma, Pistoja to Bologna, Ancona to Rome, the Sulmona-Pescara line, Naples to Foggia, Salerno to Tarento, and others. The inhabitants of the once inaccessible Abruzzis have now almost entirely abandoned their brigand habits, and are taking to the breeding of silkworms and the spinning of silk. Many of them, being still desperately poor, emigrate every summer as labourers to the big estates of the Agro Romano, between the Tiber and Civitavecchia.

See PARTSCH, in *Verhandlungen d. Ges. f. Erdkunde zu Berlin*, vol. i. (1889).—MARINELLI, in *Atti* of the First Italian Geog. Congress, vol. ii. 2, pp. 687 *et seq.*; GLOBUS, vol. lxxvi. (1899); and for the meteorology, *Annuario Statistico Italiano*, 1895 (Rome, 1896). (J. T. BE.)

APOCALYPTIC AND APOCRYPHAL LITERATURE.

THE apocalyptic and apocryphal books of Scripture have been generally treated under two distinct heads, but such a method is certainly unadvisable, since the former literature constitutes in reality a subdivision of the latter. For a general introduction to both these literatures the reader should consult *Ency. Brit.* ii. 174-184; *Ency. Biblica*, i. 213-215, 249-250; Hastings' *Dictionary of the Bible*, i. 109-123; Kautzsch, *Apokryphen u. Pseudepigraphen*, i. pp. xi.-xxiii.

Biblical Apocrypha.—These books will be dealt with under their appropriate heads. They stand in the English Bible in the following order:—1 Esdras, 2 Esdras, Tobit, Judith, Additions to Esther, Wisdom of Solomon, Ecclesiasticus, Baruch, Epistle of Jeremy, Additions to Daniel (Song of the Three Holy Children, History of Susannah, and Bel and the Dragon), Prayer of Manasseh, 1 Maccabees, 2 Maccabees. It is hardly possible to form any classification which is not open to some objection. In any case the classification must be to some extent provisional, since scholars are still divided as to the original language, date, and place of composition of some of the books which must come under our classification.[1] In the first place, we must treat separately the Old Testament and the New Testament literature of this nature. In the next place we must discriminate (I.) the Palestinian and (II.) the Hellenistic literature of the Old Testament. The former was generally written in Hebrew or Aramaic, and seldom in Greek; the latter naturally in Greek. Next, within these literatures we shall distinguish three or four classes according to the nature of the subject with which they deal. Thus the books of which we have to treat will be classed as—(i.) Historical, (ii.) Legendary (Haggadic), (iii.) Apocalyptic, (iv.) Sapiential, or belonging to the Wisdom Literature.

Classification.

OLD TESTAMENT APOCALYPTIC AND APOCRYPHAL LITERATURE.

I.—PALESTINIAN JEWISH LITERATURE.

(i.) *Historical.*

1 Ezra.
1 Maccabees.
History of Johannes Hyrcanus.

(ii.) *Legendary.*

Book of Baruch.
Rest of the Words of Baruch.
Martyrdom of Isaiah.
Book of Jubilees.
Judith.
Pseudo-Philo's Liber Antiquitatum.
Book of Adam.
Jannes and Jambres.
Joseph and Asenath.

(iii.) *Apocalyptic.*

Apocalypse of Abraham.
Apocalypse of Baruch.
Ethiopic Book of Enoch.
4 Ezra.
Assumption of Moses.
Book of Noah.
Testament of the XII Patriarchs.
Psalms of Solomon.
Prayer of Joseph.
Book of Eldad and Modad.
Apocalypse of Elijah.
Apocalypse of Zephaniah.

(iv.) *Wisdom Literature.*

Pirke Aboth.
Sirach.

II.—HELLENISTIC JEWISH LITERATURE.

(i.) *Historical and Legendary.*

Additions to Daniel.
Additions to Esther.
Epistle of Jeremy.
2 Maccabees.
3 Maccabees.
Prayer of Manasseh.
Tobit.

(ii.) *Apocalyptic.*

Slavonic Enoch.
Oracles of Hystaspes.
Testament of Job.
Testaments of the III Patriarchs.
Sibylline Oracles.

(iii.) *Wisdom Literature.*

4 Maccabees.
Wisdom of Solomon.

I.—PALESTINIAN JEWISH LITERATURE.

(i.) *Historical.*

1 *Ezra* or *Esdras.*—This book called Ἔσδρας ὁ in the LXX. and "Liber tertius Esdræ" in the Vulgate (see *Ency. Brit.* viii. 541-542) may safely be regarded as a translation from a Hebrew-Aramaic original with the exception of the independent section iii. 1-v. 6, which is probably from the Greek (see Nestle, *Marginalien und Materialien*, 1893, pp. 23-29; Thackeray in Hastings' *Bible Dict.* i. 758-763; Volz in *Ency. Biblica*, ii. 1488-1494). Since, with the above-named exception, this book is an early translation from a text superior in many instances to that of the canonical books of 2 Chronicles, Ezra, and Nehemiah, so far as these deal with the rebuilding of the temple, it is of no little value in the critical emendation of the texts of those books (Driver, *Introd. to Literature of O.T.* p. 554). Gwynn and Thackeray adduce some grounds for the view that this translation and that of the LXX. of Daniel are from the same hand (see *Dict. Christ. Biog.* iv. p. 977 note). Sir H. Howorth's opinion (*The Academy*, 1893, pp. 13, 60, 106, 174, 326, 524) that this book is more trustworthy than the canonical Ezra has much to be said in its favour. Its date is very uncertain. Schürer contents himself with saying that its composition must be placed before the time of Josephus. Fritzsche declares it cannot be earlier than the 1st century B.C. (so Ewald, De Wette).

1 *Maccabees.*—To the account of this work in *Ency. Brit.* xv. 131, it will not be necessary to add more than a few facts. The general credibility of the book is recognized by recent as well as by earlier research. Willrich (*Juden und Griechen vor der Makkab. Erhebung*, 1895) has given good grounds for assuming that the thirteen letters reproduced in the book have been added by its Greek translator from a collection of such authorities in Jerusalem.

Greek MSS. and Texts.—The following MSS. contain 1 Maccabees: ℵ, A, Codex Venetus, and 15 cursives. There are several editions of the text. The textus receptus is found in the Sixtine edition of the LXX. 1587, which is based on the Cod. Venetus and on certain unnamed cursives. This text is followed by Parsons and Holmes (*Vetus Testamentum Græce*, 5 vols. 1798-1827), who append the variants of 15 cursives, and Tischendorf (*V. T. Græce*, 2 vols. 1887). Fritzsche (*Libri apoc. V. T.* 1871) gives an independent text based on ℵ, A, Cod. Ven. and the cursives in Parsons and Holmes's edition. Finally Swete prints A with variants from ℵ and Cod. Ven. (*The Old Testament in Greek according to the Septuagint*, 3 vols. 1887-94).

---

[1] Thus some of the additions to Daniel and the Prayer of Manasses are most probably derived from a Semitic original written in Palestine, yet in compliance with the prevailing opinion they are classed under Hellenistic Jewish literature. Again, the Slavonic Enoch goes back undoubtedly in parts to a Semitic original, though most of it was written by a Greek Jew in Egypt.

Syriac and Latin Versions.—There is no ancient Ethiopic version, but there are Syriac and Latin versions. The Syriac appears in two forms: the first is that in the Peshitto from the Greek text of Lucian (preserved in the cursives 19, 64, 93); the second is that published by Ceriani from a 6th-century MS. The latter agrees more closely with the Greek, and is probably the result of a revision of the older text with the help of a Greek text (see G. Schmidt, *Zeitschrift. f. d. alttest. Wissensch.* 1897, xvii. 1-47, 233-262). There are also two forms of the old Latin version: the first is that of the Vulgate, and the second is found in a Complutensian MS. in Milan Library.

Translations and Commentaries.—The most trustworthy English translations are those in the Variorum Bible and in the Revised Version, and the best commentaries those of Rawlinson in the *Speaker's Apocrypha* and Fairweather and Black, *The First Book of Maccabees*, 1897. In German there is nothing equal to Kautzsch's translation (*Apok. und Pseud.* 1900, i. 24-81) and to Grimm's *Das erste Buch der Maccabäer erklärt*, 1853. On the literature generally, see Schürer, *Gesch. d. Jüd. Volkes*^{3}, iii. 141-146.

History of Johannes Hyrcanus.—This work is mentioned in 1 Macc. xvi. 23, 24, but no trace of its existence has been discovered elsewhere.

(ii.) *Legendary or Haggadic Works.*

Book of Baruch.—Recent criticism has in some respects diverged from the account of this book in *Ency. Brit.* iii. 404-405. Thus most scholars, such as Fritzsche, Hitzig, Kneucker, Hilgenfeld, Reuss, agree in assuming that i.-iii. 8 and iii. 9-v. 9 are from distinct writers. But some critics have gone further. Thus Rothstein (Kautzsch, *Apok. und Pseud.* i. 213-215) holds that there is no unity in iii. 9-v. 9, but that it is composed of two independent writings—iii. 9-iv. 4 and iv. 5-v. 9. Marshall (Hastings' *Bible Dict.* i. 251-254) gives a still more complex analysis. He finds in it the work of four distinct writers—i. 1-14, i. 15-iii. 8, iii. 9-iv. 4, iv. 5-v. 9. Though most modern writers, as Cornill, Gifford, Schürer, &c., advocate a Hebrew original of i.-iii. 8 and a Greek original of the rest, Rothstein, Kneucker, and Konig hold fast to the view of the older exegesis that the whole book is derived from the Hebrew. Marshall, on the other hand, argues for the view that i.-iii. 8 is translated from the Hebrew, iii. 9-iv. 4 from the Aramaic, and that iv. 5-v. 9 was originally written in Greek.

Commentaries, &c.—In addition to those enumerated in *Ency. Brit.* iii. 405, the most valuable of the more recent works is Kneucker's *Das Buch Baruch*, 1879; Gifford's in *Speaker's Apoc.* ii.

Date.—The dates of the various constituents of this book are quite uncertain. Ewald, followed by Gifford and Marshall, assigns i.-iii. 8 to the period after the conquest of Jerusalem by Ptolemy I. in 320 B.C.; Reuss to some decades later; and Fritzsche, Schrader, Keil, to the times of the Maccabees. Hitzig, Kneucker, and Schurer assume that it was written after A.D. 70. Ryle and James (*Psalms of Solomon*, pp. lxxii.-lxxvii.) hold that iv. 31-v. 9 is dependent on the Greek version of Ps. xi., and that accordingly Baruch was reduced to its present form after A.D. 70.

Rest of the Words of Baruch.—This book is most probably of Jewish authorship and its present form due to a Christian hand, as Kohler (*Jewish Quarterly Review*, 1893, pp. 407-419) has shown. It has been preserved in Greek, Ethiopic, Armenian, and Slavonic (see Schurer^3, iii. 286, 287). The Greek was first printed at Venice in 1609, and next by Ceriani in 1868 under the title "Paralipomena Jeremiæ" in his *Monumenta Sacra*, v. 11-18, and by Rendel Harris in 1889. Harris regards it in its present form as an Eirenicon addressed to the Jews by a Christian after the rebellion of Bar-Cochba.

Martyrdom of Isaiah.—This Jewish work has been in part preserved in the *Ascension of Isaiah*. To it belong i. 1, 2^a, 6^b-13^a; ii. 1-8, 10-iii. 12; v. 1^c-14 of that book. It is of Jewish origin, and recounts the martyrdom of Isaiah at the hands of Manasseh. For the Christian elements of the *Ascension of Isaiah*, see "Testament of Hezekiah" and "Vision of Isaiah."

Original Language and Date.—This was most probably written in Hebrew or Aramaic, but there is not sufficient evidence to determine this question definitely. As regards the date we may safely conclude that it was written not later than the 1st century A.D. Thus it was well known to Origen (*Ep. ad Africanum*, ix., Lommatzsch, xvii. 31; *In Matt.* xxiii. 37, Lommatzsch, iv. 237, &c.). Still earlier it was known to Tertullian (*De Pat.* 14) and to Justin Martyr (*Dial. c. Tryph.* cxx.). Thus it was current early in the 2nd century. It was probably known to the writer of the Epistle to the Hebrews (xi. 37). This brings us, if the last reference is trustworthy, to the 1st century A.D., and this no doubt is the right date, for it is highly improbable that Jewish writings of the 2nd century should gain currency in the Christian Church.

Greek Version.—The Greek version, as edited in the *Ascension*, has in part been just recovered and published by Grenfell and Hunt (*Amherst Papyri*, 1900, i. 1-22); see also Charles, *Ascension of Isaiah*, 1900, pp. xxii.-xxxiii. 84-95), where this text is critically edited and compared with all other existing authorities. This martyrdom was known to the writer of the *Opus Imperfectum* (see Montfaucon's edition of Chrysostom, vi. pp. xx. xxi.) in its original form before it was incorporated in the *Ascension* (see Charles, *op. cit.* pp. xl.-xlii., xliv. 8, 9).

Ethiopic Version.—This was first edited by Laurence in 1819 from one MS., in 1877 by Dillmann from three (*Ascensio Isaiae Æthiopice et Latine*), and in 1900 by Charles from a more accurate collation of the same three MSS., together with the other versions. This version admirably represents the original. Two of the three MSS. are excellent.

Latin Version.—Of this ii. 14-iii. 13 was discovered and edited in 1828 by Mai. This was reprinted by Dillmann in 1877 in his edition of the *Ascension*, and in 1900 by Charles after a fresh collation of the Vatican palimpsest. On the relation of the various versions, see Charles, pp. xviii.-xxxiii.

Modern Translations.—Besides Laurence's Latin and English translations, which are not trustworthy, there are Dillmann's Latin translation, Basset's French (*L'ascension d'Isaïe*, 1894), Beer's German (*Apok. und Pseud.* ii. 124-127), and Charles's English (*op. cit.* pp. 1-18, 40-42). For bibliography, see also Schurer, *Gesch. des Jüd. Volkes*^{3}, iii. 284-285.

Jubilees.—This book is variously entitled τὰ Ἰωβηλαῖα, οἱ Ἰωβηλαῖοι, ἡ λεπτὴ Γένεσις, τὰ λεπτὰ Γενέσεως, Μικρογένεσις in Greek, and "The Book of the Division" in Ethiopic. It is really an Haggadic commentary on Genesis, and is practically the sole monument of legalistic Pharisaism belonging to the latter half of the 2nd century B.C., and is a characteristic example of that form of religion against which the Pauline dialectic was directed (see *Ency. Brit.* ii. 176-177). It has a secret apologetic aim. It defends and justifies the assumption of the high priesthood by the Maccabees.

Original Language.—This book, as the production of a strict Pharisee, was naturally written in Hebrew. This Hebrew was not free from Aramaic forms, as we infer from the formation of the proper name "Mastema" and from the statement of Jerome (*Ep. ad Fabiol*, 78; *mansione*, 18). On the other hand, a large number of passages cannot be intelligibly translated unless on the presupposition of a Hebrew original (see Charles, *Ethiopic Version of Hebrew Book of Jubilees*, pp. ix. x.; Littmann in Kautzsch's *Apok. und Pseud.* ii. 34, 35). Fragments of the original Hebrew are still found in certain Midrashim.

Versions: Greek, Syriac, Ethiopic, and Latin.—Large fragments of the Greek version have come down to us in Epiphanius and such annalists as Syncellus and Cedrenus. Only a few lines survive of the Syriac. Both these were made from the original. As regards the two latter versions, which are derived from the Greek, the whole of the Ethiopic survives and about one-fourth of the Latin. The latter was first published by Ceriani in 1861, next by Ronsch (*Das Buch der Jubiläen*) in 1874, and by Charles in his edition of the Ethiopic text.

Ethiopic Text and Translations.—This text was first edited by Dillmann from two MSS. in 1859, and in 1895 by Charles from four. In the latter edition, the Greek and Latin fragments are printed together with the Ethiopic. The book was translated into German by Dillmann from one MS. in Ewald's *Jahrbücher*, ii. iii. 1850, 1851, and by Littmann (in Kautzsch's *Apok. und Pseud.* ii. 39-119) from Charles's Ethiopic text; in English by Schodde (*Bibl. Sacr.* 1885) from Dillmann's text, and by Charles (*Jewish Quarterly Review*, Oct. 1893, July 1894, Jan. 1895) from the text afterwards published in 1895.

Date and Author.—Jubilees was written after 135 B.C., when J. Hyrcanus became ecclesiastical and civil head of the nation, and before 95 B.C., when the entire body of the Pharisees was at strife with his successor Jannæus (see Bousset, *Zeitschr. f. NT.*

liche Wissenschaft, 1900, pp. 198-201). The author was not a Hellenistic Jew, as Frankel supposes, nor a Samaritan, as Beer thought, nor yet an Essene, but essentially a Pharisee in the most rigorous sense of the term (see *Ency. Biblica*, i. 232; Kautzsch, *op. cit.* ii. 36-37).

Bibliography.—See *Ency. Brit.* ii. 177; Schürer, *Gesch. d. Jüd. Volkes*, iii. 277-280. The first commentary on the whole text, by Charles, was published in 1902.

Judith.—This book (see *Ency. Brit.* xiii. 765-766) was written originally in Hebrew. This is shown not only by the numerous Hebraisms, but also by mistranslations of the Greek translation, as in ii. 2, iii. 9, and other passages (see Fritzsche and Ball *in loc.*), despite the statement by Origen (*Ep. ad Afric.* 13) that the book was not received by the Jews among their apocryphal writings. In his preface to Judith, Jerome says that he based his Latin version on the Chaldee, which the Jews reckoned among their Hagiographa. Ball (*Speaker's Apocrypha*, i. 243) holds that the Chaldee text used by Jerome was a free translation or adaptation of the Hebrew. The book exists in two forms. The shorter, which is preserved only in Hebrew (see under *Hebrew Midrashim* below), is, according to Scholz, Lipsius, Ball, and Gaster, the older. The longer form is that contained in the versions.

Greek Version.—This is found in three recensions: (1) in A B, ℵ; (2) in codices 19, 108 (Lucian's text); (3) in cod. 58, the source of the Old Latin and Syriac.

Syriac and Latin Versions.—Two Syriac versions were made from the Greek—the first, that of the Peshitto; and the second, that of Paul of Tella, the so-called Hexaplaric. The Old Latin was derived from the Greek, as we have remarked above, and Jerome's from the Old Latin, under the control of a Chaldee version.

Later Hebrew Midrashim.—These are printed in Jellinek's *Bet ha-Midrasch*, i. 130-131; ii. 12-22; and by Gaster in *Proceedings of the Society of Biblical Archæology*, 1894, pp. 156-163.

Date.—The book in its fuller form was most probably written in the 1st century, before the Christian era. The writer places his romance three centuries earlier, in the time of Ochus, as we may reasonably infer from the attack made by Holofernes and Bagoas on Judæa; for Artaxerxes Ochus made an expedition against Phœnicia and Egypt in 350 B.C., in which his chief generals were Holofernes and Bagoas.

Recent Literature.—Ball, *Speaker's Apocrypha*, 1888, an excellent piece of work; Scholz, *Das Buch Judith*^{2}, 1896; Lohr, *Apok. und Pseud.* 1900, ii. 147-164; Porter in Hastings' *Bible Dict.* ii. 822-824; Gaster, *Ency. Biblica*, ii. 2642-2646. See Ball, pp. 260-261, and Schürer, *in loc.*, for a full bibliography.

Pseudo-Philo's Liber Antiquitatum Biblicarum.—Though the Latin version of this book was thrice printed in the 16th century (in 1527, 1550, and 1599), it was practically unknown to modern scholars till it was recognized by Conybeare and discussed by Cohn in the *Jewish Quarterly Review*, 1898, pp. 279-332. It is an Haggadic revision of the Biblical history from Adam to the death of Saul. Its chronology agrees frequently with the LXX. against that of the Massoretic text, though conversely in a few cases. The Latin is undoubtedly translated from the Greek. Greek words are frequently transliterated. While the LXX. is occasionally followed in its translation of Biblical passages, in others the Massoretic is followed against the LXX., and in one or two passages the text presupposes a text different from both. On many grounds Cohn infers a Hebrew original. The eschatology is similar to that taught in the similitudes of the Book of Enoch. In fact, Eth. En. li. 1 is reproduced in this connexion. Prayers of the departed are said to be valueless. The book was written after A.D. 70; for, as Cohn has shown, the exact date of the fall of Herod's temple is predicted.

Lost Legends—The Adam Books.—That there was a Jewish book or books of Adam, which recounted the life of Adam and Eve after the Fall, we must conclude from the host of Christian apocryphs which have this subject for their theme. These are found in Greek, Syriac, Ethiopic, Arabic, Armenian. A Jewish book of Adam is mentioned in the Talmud and likewise in the *Constitutiones Apost.* vi. 16. See Smith's *Dictionary of Christian Biography*, i. 34-39; *Ency. Bibl.* i. 253; Schürer, *Gesch. d. Jüd. Volkes*, iii. 287-289.

Jannes and Jambres.—These two men are referred to in 2 Tim. iii. 8 as the Egyptian magicians who withstood Moses. The book which treats of them is mentioned by Origen (*ad Matt.* xxiii. 37 and xxvii. 9 [*Jannes et Mambres Liber*]), and in the Gelasian Decree as the *Pœnitentia Jamnis et Mambre.* The names in Greek are generally Ἰαννῆς καὶ Ἰαμβρῆς (= ינים וימברים) as in the Targ.-Jon. on Exod. i. 15; vii. 11. In the Talmud they appear as יוחני וממרא. Since the western text of 2 Tim. iii. 8 has Μαμβρῆς, Westcott and Hort infer that this form was derived from a Palestinian source. These names were known not only to Jewish but also to heathen writers, such as Pliny and Apuleius. The book, therefore, may go back to pre-Christian times. (See Schürer^3, iii. 292-294; *Ency. Biblica*, ii. 2327-2329.)

Joseph and Asenath.—The statement in Gen. xli. 45, 50 that Joseph married the daughter of a heathen priest naturally gave offence to later Judaism, and gave rise to the fiction that Asenath was really the daughter of Shechem and Dinah, and only the foster-daughter of Potipherah (*Targ.-Jon.* on Gen. xli. 45; Tractat. *Sopherim*, xxi. 9; *Jalkut Shimoni*, c. 134. See Oppenheim, *Fabula Josephi et Asenethae*, 1886, pp. 2-4). Origen also was acquainted with some form of the legend (*Selecta in Genesin*, ad Gen. xli. 45, ed. Lommatzsch, viii. 89-90). The Christian legend, which is no doubt in the main based on the Jewish, is found in Greek, Syriac, Armenian, Slavonic, and mediæval Latin. Since it is not earlier than the 3rd or 4th century, it will be sufficient here to refer to Smith's *Dict. of Christ. Biog.* i. 176-177; Hastings' *Bible Dict.* i. 162-163; Schürer, iii. 289-291.

(iii.) *Apocalyptic Literature.*

Apocalypse of Abraham.—This book is found only in the Slavonic (edited by Bonwetsch, *Studien zur Geschichte d. Theologie und Kirche*, 1897), a translation from the Greek. It is of Jewish origin, but in part worked over by a Christian reviser. The first part treats of Abraham's conversion, and the second forms an apocalyptic expansion of Gen. xv. This book was possibly known to the author of the *Clem. Recognitions*, i. 32, a passage, however, which may refer to Jubilees. It is most probably distinct from the ἀποκάλυψις Ἀβραάμ used by the Gnostic Sethites (Epiphanius, *Hær.* xxxix. 5), which was very heretical. On the other hand, it is probably identical with the apocryphal book Ἀβραάμ mentioned in the Stichometry of Nicephorus, and the Synopsis Athanasii, together with the Apocalypses of Enoch, &c.

Syriac Apocalypse of Baruch.—This apocalypse has survived only in the Syriac version, of which Ceriani discovered a 6th-century MS. in the Milan Library. Of this he published a Latin translation in 1866 (*Monumenta Sacra*, I. ii. 73-98), which Fritzsche reproduced in 1871 (*Libri Apocryphi V. T.* pp. 654-699), and the text in 1871 (*Mon. Sacra*, V. ii. 113-180), and subsequently in photo-lithographic facsimile in 1883. Chaps. lxxviii.-lxxxvi., indeed, of this book have long been known. These constitute Baruch's epistle to the nine and a-half tribes in captivity, and have been published in Syriac and Latin in the London and Paris Polyglots, and in Syriac alone from one MS. in Lagarde's *Libri V. T. Apocryphi Syr.* 1861; and by Charles from ten MSS. (*Apocalypse of Baruch*, 1896, pp. 124-167). The entire book was translated into English by the last-named writer (*op. cit.* pp. 1-167), and into German by Ryssel (Kautzsch's *Apok. und Pseud.* 1900, ii. pp. 413-446). The Syriac is translated from the Greek; for Greek words are occasionally transliterated, and passages can be explained only on the hypothesis that the wrong alternative meanings of certain Greek words were followed by the translator. The Greek in turn is derived from the Hebrew, for unintelligible expressions in the Syriac can be explained and the text restored by retranslation into Hebrew. Many *paronomasiæ* discover themselves in the course of such retranslation (see Charles, *Apoc. Bar.* pp. xliv.-liii.). The necessity of postulating a Hebrew original was first shown by the present writer, and has since been maintained by Wellhausen (*Skizzen u. Vorarbeiten*, vi. 234) and by Ryssel (*Apok. und Pseudepig. A. T.* 1900, ii. 411). The final editor of the work writes in the name of Baruch, the son of Neriah. The time extends from the eve of the capture of Jerusalem by the Chaldees till after its accomplishment. If the letter to the tribes in captivity (lxxviii.-lxxxvi.) be disregarded, the book falls into seven sections separated by fasts, save in one case (after xxxv.) where the text is probably defective. These sections, which are of unequal length, are—(1) i.-v. 6; (2) v. 7-viii.; (3) ix.-xii. 4; (4) xii. 5-xx.; (5) xxi.-xxxv.; (6) xxxvi.-xlvi.; (7) xlvii.-lxxvii. These treat of the Messiah and the Messianic kingdom, the woes of Israel in the past and the destruction of Jerusalem in the present, as well as of theological questions relating to original sin, free will, works, the number of the saved, the nature of the resurrection body, &c. The views expressed on several of the above subjects are often conflicting. In one class of passages there is everywhere manifest a vigorous optimism as to Israel's ultimate well-being on earth, and the blessedness of the chosen people in the Messianic kingdom is sketched in glowing and sensuous colours (xxix., xxxix.-xl., lxiii.-lxxiv.). Over against these passages stand others of a hopelessly pessimistic character, wherein, alike as to Israel's present and future destiny on earth, there is written nothing save "lamentation, and mourning, and woe." The world is a scene of corruption, its evils are irremediable, its end is nigh, and the advent of the new and spiritual world at hand. The first to draw attention to the composite elements in this book was Kabisch (*Jahrbücher f. protest. Theol.* 1891, pp. 66-107). This critic regarded xxiv. 3-xxix., xxxvi.-xl., and liii.-lxxiv. as independent sources written before the fall of Jerusalem, A.D. 70, and his groundwork, which consists of the rest of his book, with the exception of a few verses, as composed after that date. All these elements were put together by a Christian contemporary of Papias. Many of these conclusions were arrived at independently by a French scholar, De Faye (*Les Apocalypses Juives*, 1892, pp. 25-28, 76-103, 192-204). The present writer (*Apocalypse of Baruch*, 1896, pp. liii.-lxvii.), after submitting the book to a fresh study, has come to the following conclusions:—The book is of Pharisaic authorship and composed of six independent writings—A^1, A^2, A^3, B^1, B^2, B^3. The first three were composed when Jerusalem was still standing and the Messiah and the Messianic kingdom were expected: A^1, a mutilated apocalypse = xxvii.-xxx. 1; A^2, the Cedar and Vine Vision = xxxvi.-xl.; A^3, the Cloud Vision = liii.-lxxiv. The last three were written after A.D. 70, and probably before 90. Thus B^3 = lxxxv. was written by a Jew in exile, who, despairing of a national restoration, looked only for a spiritual recompense in heaven. The rest of the book is derived from B^1 and B^2, written in Palestine after A.D. 70. These writings belong to very different types of thought. In B^1 the earthly Jerusalem is to be rebuilt, but not so in B^2: in the former the exiles are to be restored, but not in the latter; in the former a Messianic kingdom without a Messiah is expected, but no earthly blessedness of any kind in the latter, &c. B^1 = i.-ix. 1, xxxii. 2-4, xliii.-xliv. 7, xlv.-xlvi., lxxvii.-lxxxii., lxxxiv., lxxxvi.-lxxxvii. B^2 = ix.-xxv., xxx. 2-xxxv., xli.-xlii., xliv. 8-15, xlvii.-lii., lxxv.-lxxvi., lxxxiii.

The above critical analyses were attacked and rejected by Clemen (*Stud. und Krit.* 1898, 211 *sqq.*). He fails, however, in many cases to recognize the difficulties at issue, and those which cannot be ignored he sets down to the conflicting apocalyptic traditions on which the author was obliged to draw for his subject-matter. Though Ryssel (Kautzsch, *Apok. u. Pseud. des A. T.* ii. 409) has followed Clemen, neither has given any real explanation of the disorder of the book as it stands at present.

Relation to 4 Ezra.—The affinities of this book and 4 Ezra are so numerous (see Charles, *op. cit.* 170-171) that Ewald and Ryle assumed identity of authorship. But their points of divergence are so weighty (see *op. cit.* pp. lxix.-lxxi.) that this view cannot be sustained. Three courses still remain open. If we assume that both works are composite, we shall perforce admit that some of the constituents of 4 Ezra are older than the latest of Baruch and that other constituents of Baruch are decidedly older than the remaining ones of 4 Ezra. On the other hand, if we assume unity of authorship, it seems impossible to arrive at finality on the chronological relations of these two works. Langen, Hilgenfeld, Wieseler, Stähelin, Renan, Hausrath, Drummond, Dillmann, Rosenthal, Gunkel, have maintained on various grounds the priority of 4 Ezra; and Schürer, Bissell, Thomson, Deane, Kabisch, De Faye, Wellhausen, and Ryssel the priority of Baruch on grounds no less convincing.

Integrity of the Book.—In lxxvii. 19 it is said that Baruch wrote two epistles, one to the nine and a-half tribes and the other to the two and a-half at Babylon. The former is found in lxxviii.-lxxxvi.; the latter is lost, but is probably preserved either wholly or in part in the Book of Baruch, iii. 9-iv. 29 (see Charles, *op. cit.* pp. lxv.-lxvii.). On the other hand, it is not necessary to infer from lxxv. that an account of Baruch's assumption was to be looked for in the book.

Literature.—In addition to the works cited above, see Rosenthal, *Vier apokryphische Bücher*, 1885, pp. 72-103; Deane, *Pseudepigrapha*, 1891, pp. 130-162. For a full bibliography see Schürer, *Gesch. d. Jüd. Volkes*³, 1898, iii. 223-232, and Charles (*op. cit.* pp. xxx.-xlii.).

Ethiopic Book of Enoch.—This is the most important of all the apocryphal or pseudepigraphal writings for the history of religious thought (see Charles, *Book of Enoch*, 33-53, 312-317, *Eschatology: Hebrew, Jewish, and Christian*, 1899, pp. 182-192, 203-219). It is quoted by name as a genuine production in the Epistle of Jude 14 *sq.*, and it lies at the base of Matt. xix. 28 and John v. 22, 27, and other passages. It had also a vast indirect influence on the Palestinian literature of the 1st century of our era. Like the Pentateuch, the Psalms, the Megilloth, the Pirke Aboth, this work was divided into five parts, with the critical discussion of which we shall deal below. Modern scholars are agreed that Enoch was originally written in Hebrew or Aramaic. Halévy, *Journal Asiatique*, 1867, pp. 352-395, is in favour of the former view; but the latter is now more generally advocated on the ground of Aramaic forms in the Gizeh Greek fragment, φουκα, xviii. 8, from פוכא μανδοβαρα in xxviii. 1, and βαβδηρα in xxix. 1, from כרוב and χερουβιν in xiv. 11, 18. On the other hand, it must be remembered that some Aramaic forms are found in the LXX. and in the Ethiopic version of the Old Testament. Hence, in the face of the powerful arguments of Halévy for a Hebrew original, the question cannot be regarded as yet settled. The Semitic original was translated into Greek. It is not improbable that there were two distinct Greek versions. Of the one several fragments have been preserved in Syncellus (A.D. 800), vi.-ix. 4, viii. 4-x. 14, xv. 8-xvi. 1; of the other i.-xxxii. in the Gizeh Greek fragment discovered in Egypt and published by Bouriant, *Fragments grecs du livre d'Enoch*, in 1892, and subsequently by Lods, Dillmann, Charles, Swete, and finally by Flemming and Radermacher. In addition to these fragments there is that of lxxxix. 42-49 (see Gildemeister in the *ZDMG*, 1855, pp.

621-622, and Charles, *op. cit.* 238-240). Of the Latin version only i. 9 survives, being preserved in the Pseudo-Cyprian's *Ad Novatianum* and cvi. 1-18 discovered by James in an 8th-century MS. of the British Museum (see James, *Apoc. Anecdota*, 146-150, Charles, *op. cit.* 372-375). This version is made from the Greek. The Ethiopic version, which is a very faithful translation of the Greek, alone preserves the entire text. It was edited by Laurence in 1838 from one MS. and in 1851 by Dillmann from five. The present writer has undertaken a text based on a study of twenty-five MSS.

Translations and Commentaries.—Laurence, *The Book of Enoch*, Oxford, 1821; Dillmann, *Das Buch Henoch*, 1853; Schodde, *The Book of Enoch*, 1882; Charles, *The Book of Enoch*, 1893; Beer, "Das Buch Henoch" in Kautzsch's *Apok. u. Pseud. des A. T.* 1900, ii. 217-310; Flemming and Radermacher, *Das Buch Henoch*, 1901. *Critical Inquiries.*—The bibliography will be found in Schürer, *Gesch. d. Jüdischen Volkes*^{3}, iii. 207-209, and a short critical account of the most important of these in Charles, *op. cit.* pp. 9-21.

We have remarked above that the *Book of Enoch* is divided into five parts—i.-xxxvi., xxxvii.-lxxi., lxxii.-lxxxii., lxxxiii.-xc., xci.-cviii. Some of these parts constituted originally separate treatises. In the course of their reduction and incorporation into a single work they suffered much mutilation and loss. From an early date the compositeness of this work was recognized. Scholars have varied greatly in their critical analyses of the work (see Charles, *op. cit.* 6-21, 309-311; Hastings' *Dict. of the Bible*, i. 706; *Ency. Biblica*, i. 221-222; Schodde, *Book of Enoch*, 1882, pp. 19-32). The analysis which gained most acceptation was that of Dillmann (Herzog's *Real Enkyk.*^{2} xii. 350-352), according to whom the present books consist of—(1) the groundwork, *i.e.*, i.-xxxvi., lxxii.-cv., written in the time of John Hyrcanus; (2) xxxvii.-lxxi., xvii.-xix., before 64 B.C.; (3) the Noachic fragments, vi. 3-8, viii. 1-3, ix. 7, x. 1, 11, xx., xxxix. 1, 2^a, liv. 7-lv. 2, lx., lxv.-lxix. 25, cvi.-cvii.; and (4) cviii. from a later hand. With much of this analysis there is no reason to disagree. The similitudes are undoubtedly of different authorship from the rest of the book, and certain portions of the book are derived from the *Book of Noah*. On the other hand, the so-called groundwork has no existence unless in the minds of earlier critics and some of their belated followers in the present. It springs from at least four hands, and may be roughly divided into four parts, corresponding to the present actual divisions of the book. Of these we shall deal with the easiest first. *Ch. lxxii.-lxxxii.* constitutes a work in itself, the writer of which had very different objects before him from the writers of the rest of the book. His sole aim is to give the law of the heavenly bodies. His work has suffered disarrangements and interpolations at the hands of the editor of the whole work. Thus lxxx. *sq.* are intrusions, and lxxxii. should stand before lxxix., for the opening words of the latter suppose it to be already read. *Chaps. lxxxiii.-xc.*—This section was written before 161 B.C., for "the great horn," who is Judas the Maccabee, was still warring when the author was writing. (Dillmann, Schurer, and others take the great horn to be John Hyrcanus, but this interpretation does violence to the text.) These chapters recount three visions: the first two deal with the first-world judgment; the third with the entire history of the world till the final judgment. An eternal Messianic kingdom at the close of the judgment is to be established under the Messiah, with its centre in the New Jerusalem set up by God Himself. *Chaps. xci.-civ.*—In the preceding section the Maccabees were the religious champions of the nation and the friends of the Chasids. Here they are leagued with the Sadducees, and are the declared foes of the Pharisaic party. This section was written therefore after 134 B.C., when the breach between John Hyrcanus and the Pharisees took place and before the savage massacres of the latter by Jannæus in 95 B.C.; for it is not likely that in a book dealing with the sufferings of the Pharisees such a reference would be omitted. These chapters indicate a revolution in the religious hopes of the nation. An eternal Messianic kingdom is no longer anticipated, but only a temporary one, at the close of which the final judgment will ensue. The righteous dead rise not to this kingdom but to spiritual blessedness in heaven itself—to an immortality of the soul. This section also has suffered at the hands of the final editor. Thus xci. 12-17, which describe the last three weeks of the Ten-Weeks Apocalypse, should be read immediately after xciii. 1-10, which recount the first seven weeks of the same apocalypse. But, furthermore, the section obviously begins with xcii. "Written by Enoch the scribe," &c. Then comes xci. 1-10 as a natural sequel. The Ten-Weeks Apocalypse, xciii. 1-10, xci. 12-17, if it came from the same hand, followed, and then xciv. The attempt (by Clemen and Beer) to place the Ten-Weeks Apocalypse before 167, because it makes no reference to the Maccabees, is not successful: for where the history of mankind from Adam to the final judgment is despatched in sixteen verses, such an omission need cause little embarrassment, and still less if the author is the determined foe of the Maccabees, whom he would undoubtedly have stigmatized as apostates, if he had mentioned them at all, just as he similarly brands all the Sadducean priesthood that preceded them to the time of the captivity. This Ten-Weeks Apocalypse, therefore, we take to be the work of the writer of the rest of xci.-civ. *Chaps. i.-xxxvi.*—This is the most difficult section in the book. It is very composite. Ch. vi.-xi. is apparently an independent fragment of the Enoch Saga. It is itself compounded of the Semjaza and Azazel myths, and in its present composite form is already presupposed by lxxxviii.-lxxxix. 1; hence its present form is earlier than 166 B.C. It represents a primitive and very sensuous view of the eternal Messianic kingdom on earth, seeing that the righteous beget 1000 children before they die. In the next place xii.-xvi. stand quite apart from the rest of i.-xxxvi. owing to the transcendent picture they give of God as contrasted with what is given in the rest of the section. Likewise they represent what Enoch saw in a dream, whereas xvii.-xxxvi. recount Enoch's actual journeys through the heavens. These chapters were probably an independent fragment of the Enoch Saga. Again, xvii.-xix. stand in a peculiar relation to xx.-xxxvi., since both sections deal with the same subjects. Thus xvii. 4 = xxiii.; xvii. 6 = xxii.; xviii. 1 = xxxiv.-xxxvi.; xviii. 6-9 = xxiv.-xxv., xxxii. 1-2; xviii. 11, xix. = xxi. 7-10; xviii. 12-16 = xxi. 1-6. They belong to the same cycle of tradition and cannot be independent of each other. Chap. xx. appears to show that xx.-xxxvi. is fragmentary, since only four of the seven angels mentioned in xx. have anything to do in xxi.-xxxvi. *Chaps. xxxvii.-lxx.*—These constitute the well-known similitudes. They were written before 64 B.C., for Rome was not yet known to the writer, and after 95 B.C., for the slaying of the righteous, of which the writer complains, was not perpetrated by the Maccabean princes before that date. This section consists of three similitudes—xxxviii.-xliv., xlv.-lvii., lviii.-lxix. These are introduced and concluded by xxxvii. and lxx. There are many interpolations—lx., lxv.-lxix. 25 come confessedly from the *Book of Noah*; most probably also liv. 7-lv. 2. Whence others, such as xxxix. 1, 2^a, xli. 3-8, xliii. *sq.*, spring is doubtful. Ch. l., lvi. 5-lvii. 3^a are likewise insertions, and lxxi. an addition, at variance with the thought of the section. The Messianic doctrine and eschatology of this section is unique. The Messiah is here for the first time described as the pre-existent Son of Man, who possesses universal dominion and is the Judge of all mankind. After the judgment there will be a new heaven and a new earth, which will be the abode of the blessed.

4 *Ezra.*—This apocryph had a very wide circulation among the Greek and Latin fathers. In the Latin version it consists of sixteen chapters, of which, however, only iii.-xiv. are found in the other versions. To iii.-xiv., accordingly, the present notice is confined. After the example of most of the Latin MSS. we designate the book 4 Ezra (see Bensly-James, *Fourth Book of Ezra*, pp. xxiv.-xxvii.). In the first Arabic and Ethiopic versions it is called 1 Ezra; in some Latin MSS. and in the English Authorized Version it is 2 Ezra, and in the Armenian 3 Ezra. Chapters i.-ii. are sometimes called 3 Ezra, and xv.-xvi. 5 Ezra. All the versions go back to a Greek text. This is shown by the late Greek apocalypse of Ezra (Tischendorf, *Apocalypses Apocryphæ*, 1866, pp. 24-33), the author of which was acquainted with the Greek of 4 Ezra; also by quotations from it in Barn. iv. 4; xii. 1 = 4 Ezra xii. 10 *sqq.*, v. 5; Clem. Alex. *Strom.* iii. 16 (here first expressly cited) = 4 Ezra, v. 35, &c. (see Bensly-James, *op. cit.* pp. xxvii.-xxxviii.). In his *Messias Judæorum*, 1869, pp. 36-110, Hilgenfeld has given a reconstruction of the Greek text. Till 1896 only Ewald believed that 4 Ezra was written originally in Greek. In that year Wellhausen (*Gött. Gel. Anz.* pp. 12-13), and Charles (*Apoc. Bar.* p. lxxii.) pointed out that a Hebrew original must be assumed on various grounds; and this view the former established in his *Skizzen u. Vorarbeiten*, vi. 234-240, 1899. Of the numerous grounds for this assumption it will be necessary only to adduce such constructions as "de quo me interrogas de eo," iv. 28, and xiii. 26 "qui per semet ipsum liberabit" (= בו יושיע) = "through whom he will deliver," or to point to such a mistranslation as vii. 33, "longanimitas congregabitur," where for "congregabitur" (= יאסף) we require "evanescet," which is another and the actual meaning of the Hebrew verb in this passage. The same mistranslation is found in the Vulgate in Hosea iv. 3. This view has been adopted in Gunkel's German translation of Ezra (Kautzsch, *Apok. u. Pseud. d. A. T.* ii. 332-333).

Latin Version.—All the older editions of this version, as those of Fabricius, Sabatier, Volkmar, Hilgenfeld, Fritzsche, as well as in the older editions of the Bible, are based ultimately on only one MS., the Codex Sangermanensis (written A.D. 822), as Gildemeister proved in 1865 from the fact that the large fragment between verses 36 and 37 in chapter vii., which is omitted in all the above editions, originated through the excision of a leaf in this MS. A splendid edition of this version based on MSS. containing the missing fragment, which have been subsequently discovered, has been published by Bensly-James (*op. cit.*). This edition has taken account of all the important MSS. known, save one at Leon in Spain.

Syriac Version.—This version, found in the Ambrosian Library in Milan, was translated into Latin by Ceriani, *Monumenta sacra et profana*, II. ii. pp. 99-124, 1866. Two years later this scholar edited the Syriac text, *op. cit.* V. i. pp. 4-111, and in 1883 reproduced the MS. by photo-lithography (*Translatio Syra Peshitto V. T.* II. iv. pp. 553-572). Hilgenfeld incorporated Ceriani's Latin translation in his *Messias Judæorum*. This translation needs revision and correction.

Ethiopic Version.—First edited and translated by Laurence, *Primi Ezræ Libri Versio Æthiopica*, 1820. Laurence's Latin translation was corrected by Prætorius and reprinted in Hilgenfeld's *Messias Judæorum*. In 1894 Dillmann's text based on ten MSS. was published—*V. T. Æth. Libri Apocryphi*, v. 153-193.

Arabic Versions.—The first Arabic version was translated from a MS. in the Bodleian Library into English by Ockley (in Whiston's *Primitive Christianity*, vol. iv. 1711). This was done into Latin and corrected by Steiner for Hilgenfeld's *Mess. Jud.* The second Arabic version, which is independent of the first, has been edited from a Vatican MS. and translated into Latin by Gildemeister, 1877.

Armenian Version.—First printed in the Armenian Bible, 1805. Translated into Latin by Petermann for Hilgenfeld's *Mess. Jud.*

Relation of the above Versions.—These versions stand in the order of worth as follows:—Latin, Syriac, Ethiopic. The remaining versions are paraphrastic and less accurate, and are guilty of additions and omissions. All the versions, save the second Arabic one, go back to the same Greek version. The second Arabic version presupposes a second Greek version.

Modern Versions.—All the English versions are now antiquated, except those in the Variorum Apocrypha and the Revised Version of the Apocrypha, and even these are far from satisfactory. Similarly, all the German versions are behindhand, except the excellent version of Gunkel in *Apok. u. Pseud.* ii. 252-401, which, however, needs occasional correction.

The book (iii.-xiv.) consists of seven visions or parts, like the apocalypse of Baruch. They are: (1) iii. 1-v. 19; (2) v. 20-vi. 34; (3) vi. 35-ix. 25; (4) ix. 26-x. 60; (5) xi. 1-xii. 51; (6) xiii.; (7) xiv. These deal with (1) religious problems and speculations (2) and eschatological questions. The first three are devoted to the discussion of religious problems affecting in the main the individual. The pre-suppositions underlying these are in many cases the same as those in the Pauline Epistles. The next three visions are principally concerned with eschatological problems which relate to the nation. The seventh vision is a fragment of the Ezra Saga recounting the rewriting of the Scriptures, which had been destroyed. This has no organic connexion with what precedes. According to Gunkel (*Apok. u. Pseud.* ii. 335-352) the whole book is the work of one writer. Thus down to vii. 16 he deals with the problem of the origin of suffering in the world, and from vii. 17 to ix. 25 with the question who is worthy to share in the blessedness of the next world. As regards the first problem the writer shows, in the first vision, that suffering and death come from sin—no less truly on the part of Israel than of all men, for God created man to be immortal; that the end is nigh, when wrongs will be righted; God's rule will then be recognized. In the second he emphasizes the consolation to be found in the coming time, and in the third he speaks solely of the next world, and then addresses himself to the second problem. The fourth, fifth, and sixth visions are eschatological. In these the writer turns aside from the religious problems of the first three visions and concerns himself only with the future national supremacy of Israel. Zion's glory will certainly be revealed (vision four), Israel will destroy Rome (five) and the hostile Gentiles (six). Then the book is brought to a close with the legend of Ezra's restoration of the lost Old Testament Scriptures.

In the course of the above work there are many inconsistencies and contradictions. These Gunkel explains by admitting that the writer has drawn largely on tradition, both oral and written, for his materials. Thus he concedes that eschatological materials in v. 1-13, vi. 18-28, vii. 26 *sqq.*, also ix. 1 *sqq.*, are from this source, and apparently from an originally independent work, as Kabisch urges, but that it is no longer possible to separate the borrowed elements from the text. Again, in the four last visions he is obliged to make the same concession on a very large scale. Vision four is based on a current novel, which the author has taken up and put into an allegorical form. Visions five and six are drawn from oral or written tradition, and relate only to the political expectations of Israel, and seven is a reproduction of a legend, for the independent existence of which evidence is furnished by the quotations in Bensly-James, pp. xxxvii.-xxxviii. Thus the chief champion of the unity of the book makes so many concessions as to its dependence on previously existing sources that, to the student of eschatology, there is little to choose between his view and that of Kabisch. In fact, if the true meaning of the borrowed materials is to be discovered, the sources must be disentangled. Hence the need of some such analysis as that of Kabisch (*Das vierte Buch Ezra*, 1889): S = an Apocalypse of Salathiel, circ. A.D. 100, preserved in a fragmentary condition, iii. 1-31,

iv. 1-51, v. 13*b*-vi. 10, 30-vii. 25, vii. 45-viii. 62, ix. 13-x. 57, xii. 40-48, xiv. 28-35. E = an Ezra Apocalypse, circ. 31 B.C., iv. 52-v. 13*a*, vi. 13-28, vii. 26-44, viii. 63-ix. 12. A = an Eagle Vision, circ. A.D. 90, x. 60-xii. 35. M = a Son-of-Man Vision, xiii. E^2 = an Ezra fragment, circ. A.D. 100, xiv. 1-17*a*, 18-27, 36-47. All these, according to Kabisch, were edited by a Zealot, circ. 120, who supplied the connecting links and made many small additions. In the main this analysis is excellent. If we assume that the editor was also the author of S, and that such a vigorous stylist, as he shows himself to be, recast to some extent the materials he borrowed, there remains but slight difference between the views of Kabisch and Gunkel. Neither view, however, is quite satisfactory, and the problem still awaits solution. Other attempts, such as Ewald's (*Gesch. d. Volkes Israel*^{3}, vii. 69-83) and De Faye's (*Apocalypses Juives*, 155-165), make no contribution.

Time and Place.—The work was written towards the close of the 1st century (iii. 1, 29), and somewhere in the east.

Literature.—In addition to the authorities mentioned above, see Dillmann, Herzog's *Real Enkyk.*^{2} xii. 353 *sqq.*; Schürer, *Gesch. des Jüd. Volkes*^{3}, iii. 246 *sqq.*; and the articles on 4 Esdras in Hastings' *Bible Dictionary* and the *Encyclopædia Biblica* by Thackeray and James respectively.

The Assumption of Moses.—This book was lost for many centuries till a large fragment of it was discovered and published by Ceriani in 1861 (*Monumenta Sacra*, I. i. 55-64) from a palimpsest of the 6th century. Very little was known about the contents of this book prior to this discovery. One passage found in this fragment is quoted in the *Acta Synodi Nicænæ*, ii. 18. Most of the other references relate to the strife of Michael and Satan about the body of Moses, and ascribe it the Ascensio Mosis, *i.e.*, Ἀνάληψις Μωυσέως. (Various other works have been attributed to Moses, such as the Petirath Moshe, the βίβλος λόγων Μυστικῶν Μωυσέως, The Exodus of Moses (in Slavonic), &c. See Charles, *Assumption of Moses*, pp. xiv.-xvii.; Schürer, *Gesch. des Jüd. Volkes*, iii. 220-221.)

Editions and Translations.—In addition to those mentioned in *Ency. Brit.* ii. 177, the only complete edition has been published by Charles, *The Assumption of Moses*, 1897. A German translation, with notes by Clemen, will be found in Kautzsch's *Apok. und Pseud.* ii. 311-331. That our Latin text is derived from the Greek there can be no question. Thus Greek words are transliterated, as "chedrio" from κεδρόω, "heremus" from ἐρῆμος; Greek idioms are reproduced, as "usque nos duci captivos" = ἕως τοῦ ἡμᾶς αἰχμαλωτισθῆναι, and retranslation into Greek is frequently necessary in order to correct the misrenderings of the translator or the corruptions already inherent in the Greek. Finally, fragments of the Greek version are still preserved. That the Greek was in turn derived from a Semitic original was denied by Hilgenfeld, Volkmar, and others. It is still regarded as an open question by Clemen. On the other hand, Ewald, Schmidt-Merx, Colani, Carriere, Hausrath, Dalman, Rosenthal, and others decide in favour of a Semitic. The present writer has sought at some length to prove that the Greek goes back not to an Aramaic original, but to a Hebrew (see *op. cit.* pp. xxxviii.-xlv.).

The present book is possibly the long-lost Διαθήκη Μωυσέως mentioned in some ancient lists; for it never speaks of the assumption of Moses, but always of his natural death (i. 15, iii. 13, x. 14). About a half of the original Testament is preserved in the Latin version. The latter half probably dealt with questions about the Creation. (See Fabric. *Cod. Pseud. V. T.* ii. 844; *Acta Synodi Nicænæ*, ii. 20.) With this "Testament" the "Assumption," to which almost all the patristic references and that of Jude are made, was subsequently edited. The book has been assigned to most periods between the death of Herod the Great and that of Bar-Cochba. But the text precludes any date after A.D. 70. The true date appears to lie between 4 B.C. and A.D. 30. Herod is already dead (vi. 6), hence it is after 4 B.C.; and Herod's sons are to rule for shorter periods than their father, hence it must have been composed before these princes had reigned thirty-four years—*i.e.*, before A.D. 30. It may also be shown that A.D. 7 is probably the earlier limit (see Charles, *op. cit.* pp. lv.-lviii.). As for the author, he was no Essene, for he recognizes animal sacrifices and cherishes the Messianic hope; he was not a Sadducee, for he looks forward to the establishment of the Messianic kingdom (x.); nor a Zealot, for the quietistic ideal is upheld (ix.) and the kingdom is established by God Himself (x.). He is therefore a Chasid of the ancient type, and glorifies the ideals which were cherished by the old Pharisaic party, but which were now being fast disowned in favour of a more active rôle in the political life of the nation. He pours his most scathing invectives on the Sadducees, who are described in vii. in terms that recall the anti-Sadducean *Psalms of Solomon*. His object, therefore, is to protest against the growing secularization of the Pharisaic party through its adoption of popular Messianic beliefs and political ideals.

See *Ency. Brit.* ii. 177; *Ency. Bibl.* i. 233-236; Burkitt in Hastings' *Bible Dict.* iii. 448-450; Charles, *Assumption of Moses*, 1897; Schürer, *Gesch. d. Jud. Volkes*^{3}, 1900, pp. 213-222.

Book of Noah.—Though this book has not come down to us independently, it has in large measure been incorporated in the Ethiopic *Book of Enoch*, and can in part be reconstructed from it. The *Book of Noah* is mentioned in Jubilees x. 13, xxi. 10. Ch. lx., lxv.-lxix. 25 of the Ethiopic Enoch are without question derived from it. Thus lx. 1 runs: "In the year 500, in the seventh month . . . in the life of Enoch." Here the editor simply changed the name Noah in the context before him into Enoch, for the statement is based on Gen. v. 32, and Enoch lived only 365 years. Chapters vi.-xi., cvi.-cvii. of the same book are probably from the same source; likewise liv. 7-lv. 2, and Jubilees vii. 26-39, x. 1-15. In the former passage of Jubilees the subject-matter leads to this identification, as well as the fact that Noah is represented as speaking in the first person, although throughout Jubilees it is the angel that speaks. Possibly Eth. En. xli. 3-8, xliii.-xliv., lix., are from the same work. The book may have opened with Eth. En. cvi.-cvii. On these chapters may have followed Eth. En. vi.-xi., lxv.-lxix. 25, lx., xli. 3-8, xliii.-xliv., liv. 7-lv. 2; Jubilees vii. 26-39, x. 1-15. Since some of these chapters are earlier than Eth. En. lxxxiii.-xc. and Jubilees, the original work is not later than 166 B.C. (See Hastings' *Bible Dict.* iii. 586-587.)

The Hebrew *Book of Noah*, a later work, is printed in Jellinck's *Bet ha-Midrasch*, iii. 155-156, and translated into German in Rönsch, *Das Buch der Jubilaen*, 385-387. It is based on the part of the above *Book of Noah* which is preserved in Jubilees. The portion of this Hebrew work which is derived from the older work is reprinted in Charles's Ethiopic version of the Hebrew *Book of Jubilees*, p. 179.

Testaments of the XII Patriarchs.—The earliest reference to this book is found in Origen in his *Hom. in Josuam*, xv. 6 (Ed. Lommatzsch, xi. 143): "In aliquo quodam libello qui appellatur testamentum duodecim patriarcharum, quamvis non habeatur in canone, talem tamen quendam sensum invenimus, quod per singulos peccantes singuli Satanæ intelligi debeant" (*cf.* Reuben, iii.). The Testaments are mentioned simply as Πατριάρχαι in the Stichometry of Nicephorus, the Synopsis Athanasii, and the anonymous list of books edited by Montfaucon and others. From this period the Testaments were lost sight of till the 13th century, when they were translated into Latin from a 10th-century MS. (now in Cambridge) by Grosseteste, bishop of Lincoln. The work consists of the dying commands of the twelve sons of Jacob to their children. Each testament treats of a special virtue or vice which finds illustration in the life of the particular patriarch. Three elements are distinguishable in each testament:—(1) The patriarch in each gives an account of his life, dwelling with particular emphasis on his particular virtues or vices. In many respects these accounts are of the nature of a Midrash on the Biblical notices concerning him, but in some instances they are in sharp conflict with them. (2) After the historical or legendary notices just referred to the patriarch gives appropriate exhortations, naturally suggested by the qualities conspicuous in his own career. (3) Finally he appends a series of predictions.

Grabe (*Spicileg. Patrum*^{2}, 1714, i. 129-144, 335-374) was the first to suggest that the work was written by a Jew and subsequently interpolated by a Christian. Most subsequent writers, however, rejected Grabe's view, and so the exegesis of the book became a mere series of fruitless logomachies till Schnapp revived Grabe's hypothesis in an excellent piece of work, *Die Test. der XII Patr. untersucht*, 1894, Halle. This critic has tried to prove, firstly, that in its original form the book consisted of biographical details respecting each of the patriarchs, and exhortations suggested by these details: next, that this work was revised by a Jew, who added the portions of an apocalyptic or predictive nature: and thirdly, that the book thus enlarged was revised by a Christian, who modified some passages and in others introduced interpolations. The third thesis has been confirmed by Conybeare's collation of the Armenian version (*Jewish Quarterly Review*, 1893, 387 *sqq.*; 1896, 260 *sqq.*, 471 *sqq.*) which omits most of the Christian passages in the Greek version. But Bousset has overthrown Schnapp's second thesis and shown that the apocalyptic sections belonged to the original work: see "Die Testamente der Zwölf Patriarchen" in the second number of Preuschen's *Zeitschr. f. d. NTliche Wissenschaft*.

Till the last few years it has been generally believed that the Testaments were originally written in Greek. But this appears most improbable, and there are good grounds for supposing a Semitic original. In the first place, the greater part of the work cannot be later than 100 B.C. In the next the Greek is thoroughly Semitic in character. Gaster has published a Hebrew text of the *Testament of Naphtali*, which he holds to be the original of the Greek. That this is not so, the present writer has shown in *Ency. Biblica*, i. 239-240. Gaster's text, which is a late compilation possessing some materials in common with the Greek, is nevertheless of service in explaining through the Hebrew how one hopelessly corrupt passage in the Greek arose. Furthermore, in favour of a Hebrew original, it may be urged that—(1) Hebrew constructions are frequent; (2) paronomasiæ, which are lost in the Greek but can be restored by retranslation, are frequent; and (3) certain passages which are unintelligible in the Greek become clear on retranslation. On the other hand, see Pass and Arendzen's "Fragment of an Aramaic Text of the Testament of Levi" in *Jewish Quarterly Review*, 1900, pp. 651-661.

Versions.—The Greek version was edited by Sinker from two MSS. in 1869 and the variants of two other MSS. in an appendix in 1879. This scholar has long promised a new edition from six MSS., and another is said to be in preparation by von Gebhardt. There were also early Syriac and Armenian versions. Of the former only a small fragment survives. The latter was published at Venice in 1896. Most of its variants have been made accessible through Conybeare in the *Jewish Quarterly Review* above referred to, and through "Preuschen's Die armenische Uebersetzung der Testamente der zwolf Patriarchen" in the second number of Preuschen's *Z. f. d. NTliche Wissensch. u. d. Kunde d. Urchristenthums*, 1900.

Date.—Excluding the Christian additions, which were made at different dates down to the 5th century, the work was composed towards the close of the 2nd century B.C., with the exception of Levi x. xiv.-xvi., Judah xxii.-xxv., and certain fragments in Dan. v. and Zebulon ix., which belong to the 1st century B.C. See Bousset in Preuschen's review (mentioned above), 1900, pp. 142-175, 187-209, and the articles by Charles, *in loc.*, in *Ency. Biblica*, i. 237-241, and Hastings' *Bible Dictionary*, iv.

Psalms of Solomon.—These psalms, in all eighteen, enjoyed but small consideration in early times, for only six direct references to them are found in early literature. Their ascription to Solomon is due solely to his scribes, for no such claim is made in any of the psalms.

There are only three valuable editions of the text:—Ryle and James, Ψαλμοὶ Σολομῶντος, *The Psalms of the Pharisees*, 1891, from five MSS.; Swete, *The Old Testament in Greek*, iii. 1894, 765-787, from six MSS.; Gebhardt, Ψαλμοὶ Σολομῶντος—*Die Psalmen Salomonis zum ersten Male mit Benutzung d. Athoshandschriften und d. Cod. Casanatensis*, 1895, from five MSS., three of which are used for the first time. The best recent translation into English is that of Ryle and James. It has been done into German by Wellhausen in the appendix to his *Die Pharisäer u. Sadducäer*, 1874, and recently by Kittel in Kautzsch's *Apok. u. Pseud. des A. T.* ii. 130-148. The latter translation is based on Gebhardt's text.

The second psalm was written soon after 48 B.C., for it contains a triumphant reference to Pompey's death, ii. 29-31. Pss. i., viii., and xvii. fall between 63 and 48 B.C., for they presuppose Pompey's capture of Jerusalem, but show no knowledge of his death. Pss. v., vii., ix., xiii., xv., belong apparently to the same period, but iv. and xii. to an earlier one. On the whole Ryle and James are no doubt right in assigning 70-40 B.C. as the limits within which the psalms were written. The authors were Pharisees. They divide their countrymen into two classes—"the righteous," ii. 38-39, iii. 3-5, 7, 8, &c., and "the sinners," ii. 38, iii. 13, iv. 9, &c.; "the saints," iii. 10, &c., and "the transgressors," iv. 11, &c. The former are the Pharisees; the latter the Sadducees. They protest against the Asmonæan house for usurping the throne of David and laying violent hands on the high priesthood, xvii. 5, 6, 8, and proclaim the coming of the Messiah, the Son of David, who is to set all things right and establish the supremacy of Israel. Pss. xvii.-xviii. and i.-xvi. cannot be assigned to the same authorship. The hopes of the Messiah are confined to the former, and a somewhat different eschatology underlies the two works (see Charles, *Eschatology: Hebrew, Jewish, and Christian*, 220-225). There can be no doubt that Hebrew was the original language. This would follow from the fact that they were sung in the public worship of the synagogue, as we infer from the inscriptions. But independently of this fact it is impossible to translate the Greek intelligibly, save on this hypothesis: see the excellent commentary of Ryle and James, pp. lxxvii.-lxxxvii. Since the Psalms were written in Hebrew, and intended for public worship in the synagogues, it is most probable that they were composed in Palestine. Besides, not a shred of evidence can be adduced in favour of any other country.

In addition to the literature mentioned above and in Ryle and James's edition, Schurer's *Gesch. des Jud. Volkes*^{3}, iii. 150 *sqq.*, see *Ency. Biblica*, i. 241-245.

Lost Apocalypses: Prayer of Joseph.—The *Prayer of Joseph* is quoted by Origen [*In Joann.* II. xxv. (Lommatzsch, i. 147, 148); *in Gen.* III. ix. (Lommatzsch, viii. 30-31)]. The fragments in Origen represent Jacob as speaking and claiming to be "the first servant in God's presence," "the first-begotten of every creature animated by God," and declaring that the angel who wrestled with Jacob (and was identified by Christians with Christ) was only eighth in rank. The work was obviously anti-Christian. (See Schurer^3, iii. 265-266.)

Book of Eldad and Modad.—This book was written in the name of the two prophets mentioned in Num. xi. 26-29. It consisted, according to the Targ. Jon. on Num. xi. 26-29, mainly of prophecies on Magog's last attack on Israel. The Shepherd of Hermas quotes it *Vis.* ii. 3. (See Marshall in Hastings' *Bible Dictionary*, i. 677.)

Apocalypse of Elijah.—This apocalypse is mentioned in two of the lists of books. Origen, Ambrosiaster, and Euthalius ascribe to it 1 Cor. ii. 9. If they are right, the apocalypse is pre-Pauline. The peculiar form in which 1 Cor. ii. 9 appears in Clemens Alex. *Protrept.* x. 94, and the *Const. Apost.* vii. 32 shows that both have the same source, probably this apocalypse. Epiphanius (*Hær.* xlii. (ed. Oehler, vol. ii. 678) ascribes to this work Eph. v. 14. Isr. Lévi (*Revue des Etudes Juives*, 1880, i. 108 *sqq.*) argues for the existence of a Hebrew apocalypse of Elijah from two Talmudic passages. A late work of this name has been published by Jellinek, *Bet ha-Midrasch*, 1855, iii. 65-68 and Buttenwieser in 1897. Zahn, *Gesch. des NTKanons*, ii. 801-810, assigns this apocalypse to the 2nd century A.D. (See Schurer^3, iii. 267-271.)

Apocalypse of Zephaniah.—Apart from two of the lists this work is known to us in its original form only through a citation in Clem. Alex. *Strom.* v. 11, 77. A Christian revision of it is probably preserved in the two dialects of Coptic. Of these the Achmim text is the original of the Sahidic. These texts and their translations have been edited by Steindorff, *Die Apokalypse des Elias, eine unbekannte Apokalypse und Bruchstücke der Sophonias-Apokalypse*, 1899. As Schürer (*Theol. Literaturzeitung*, 1899, No. I. 4-8) has shown, these fragments belong most probably to the Zephaniah apocalypse. They give descriptions of heaven and hell, and predictions of the Antichrist. In their present form these Christianized fragments are not earlier than the 3rd century. (See Schurer, *Gesch. des Jüd. Volkes*^{3}, iii. 271-273.)

(iv.) *Wisdom Literature.*

The Pirke Aboth.—These sayings of the Jewish fathers are preserved in the 9th Tractate of the Fourth Order of the Mishna. They are attributed to some sixty Jewish teachers, and the collection is divided into five chapters. These teachers belong for the most part to the years A.D. 70-170, though a few of them are of a much earlier date. (See P. Ewald's *Pirke Aboth*, 1825; Strack, *Die Sprüche der Väter*^{2}, 1888; Taylor, *Sayings of the Jewish Fathers*^{2}, 1899.)

Sirach or Ecclesiasticus.—This book bore the name "Proverbs" (משלים), according to Jerome. It was also known as "The Wisdom of Jesus, the son of Sirach" (Σοφία Ἰησοῦ υἱοῦ Σειράχ, or, more shortly, Σοφία Σειράχ). In the Latin Church the book was, so far as we know, first called *Ecclesiasticus* in Cyprian (*Testim.* ii. 1; iii. 1, &c.). The expression "Libri ecclesiastici" in Church writers designates the apocryphal books of the Old Testament in contradistinction from the canonical books. Among such books Ecclesiasticus was the Church book, *κατ᾽ ἐξοχήν*. The name of the author is given in the Greek of l. 27 as "Jesus, the son of Sirach," but in the Hebrew of l. 27 and li. 30 as "Simon, son of Joshua, son of Eleazar, son of Sira."

The prologue states that the Sirach's grandson went to Egypt in the 38th year of Euergetes. Since of the two Ptolemies, who bore the surname of Euergetes, the first reigned only twenty-five years, it must be the second that is referred to here, *i.e.*, Ptolemy VII. Physcon Euergetes II. This prince began to reign in 170 B.C. Hence 132 is the date of the arrival of Sirach's grandson in Egypt, and the composition of Sirach's work would be from forty to seventy years earlier. Thus the date would lie between 200 and 170 B.C. This date would harmonize well with the apparently contemporary account of the High-priest Simon II. in l. 1-26, who was in office about 200 B.C. Edersheim (*Speaker's Apocrypha*, ii. 4-9) and others contest this view. See, however, Ryssel (Kautzsch's *Apok. u. Pseud.* i. 234-239; *Ency. Biblica*, ii. 1170-1171). That this book was written in Hebrew is stated by Jerome; but, with the exception of occasional sentences in the Talmud, it was lost to modern scholarship till 1896, when chaps. xxxix. 15-xlix. 11 were published by Cowley and Neubauer. This large fragment of the original text was found in a synagogue in Cairo. The discovery and publication of further fragments have followed in fast succession. In 1899 Schechter and Taylor edited chaps. iii. 6-vii. 29; xi. 34; xii. 2-xvi. 26; xxx. 11-xxxi. 11; xxxii. 1-xxxiii. 3; xxxv. 9-20; xxxvi. 1-21; xxxvii. 27-xxxviii. 27; xlix. 12-li. 30. In the same year G. Margoliouth published in the *Jewish Quarterly Review* chaps. xxxi. 12-31; xxxvi. 22-xxxvii. 26; and on pp. 462-465 of the same review in 1900 appeared further fragments discovered by Schechter, *i.e.*, iv. 23*b*, 30-31; v. 4-7, 9-13; xxv. 8*b*, 13, 17-24; xxvi. 1-2*a*; xxxvi. 19*a*; and on pp. 466-480 fragments discovered by Adler, vii. 29-xi. 33; xii. 1; and on pp. 688-702 fragments discovered by Gaster, xviii. 31-xix. 2; xx. 5-7; xxxvii. 19, 22, 24, 26; xx. 13; and finally, in the *Revue des Etudes Juives*, 1900, pp. 1-30, the fragments discovered by Lévi—xxxvi. 24-26; xxxvii. 1-xxxviii. 1. Margoliouth's theory that these fragments are not part of the original Hebrew text, but of a mediæval Hebrew version, is rejected almost universally, both by Jewish and Christian scholars.

Versions—Greek and Syriac.—These versions are from the Hebrew. The Greek is preserved in ℵ A B C and Cod. Ven. of the Uncials, and in a large number of cursives. All these MSS. go back to the same Greek text, for they all attest the remarkable transposition in xxx.-xxxvi. The right order is preserved in the Syriac, Latin, and Arabic versions. We should, therefore, place xxx. 25-xxxiii. 13*a* after xxxiii. 13*b*-xxxvi. 16*a*. The right order appears, it is true, in Cursive 248, but the form of the text shows that the dislocation existed in the text from which it was derived, and was set right subsequently. The Greek and Syriac are invaluable in the criticism of the Hebrew fragments.

Latin and other Versions.—The Latin version, which preserves the right order in xxx.-xxxvi., and is herein followed by the English version, was made from the Greek before these chapters were dislocated. This version dates from A.D. 200-250. It occasionally preserves the right text where the Greek has since become corrupt. The Syro-Hexaplaric, Ethiopic, Armenian, and Coptic versions were derived from the Greek after the transposition of chaps. xxx.-xxxvi.

Literature.—Owing to the recent discoveries and innumerable studies on the Hebrew texts and the various versions, all the earlier works are to a great degree antiquated. The best are Fritzsche's *Die Weisheit Jesus-Sirachs*, 1859, and Edersheim's commentary in the *Speaker's Apocrypha*, ii. 1-239. In the latter work and Schurer's *Gesch. des Jüd. Volkes*,^{3} iii. 161-166, a full bibliography will be found. See particularly Toy in *Ency. Bib.* ii. 1164-1179. Smend has promised a comprehensive edition, taking into account all the most recent discovery and criticism.

II.—HELLENISTIC LITERATURE.

(i.) *Historical and Legendary.*

Additions to Daniel.—These are three in number: *Susannah and the Elders*, *Bel and the Dragon*, and *The Song of the Three Children*. Of these the two former have no organic connexion with the text. The case is otherwise with regard to the last. In some respects it helps to fill up a gap in the canonical text between verses 23 and 24 of chapter iii. And yet we find Polychronius, early in the 5th century, stating that this song was not found in the Syriac version.

Song of the Three Children.—This section is composed of the Prayer of Azariah and the Song of Azariah, Ananias, and Misael, and was inserted after iii. 23 of the canonical text of Daniel. According to Fritzsche, König, Schürer, &c., it was composed in Greek and added to the Greek translation. On the other hand, Delitzsch, Bissell, Ball, &c., maintain a Hebrew original. The latter view has been recently supported by Rothstein, *Apok. und Pseud.* i. 173-176, who holds that these additions were made to the text before its translation in Greek. These additions still preserve, according to Rothstein, a fragment of the original text, *i.e.*, verses 23-28, which came between verses 23 and 24 of chapter iii. of the canonical text. They certainly fill up excellently a manifest gap in this text. "The Song of the Three Children" was first added after the verses just referred to, and subsequently the Prayer of Azariah was inserted before these verses.

Susannah.—This addition was placed by Theodotion before chap. i., and "Bel and the Dragon" at its close, whereas by the LXX. and the Vulgate it was reckoned as chap. xiii. after the twelve canonical chapters, Bel and the Dragon as xiv. Theodotion's version is the source of the Peshitto for all three additions, and the LXX. is the source of the Syro-Hexaplaric, which has been published by Ceriani (*Mon. Sacr.* vii.). The source of the story may, according to Ewald (*Gesch.*^{3}, iv. 636), have been suggested by the Babylonian legend of the seduction of two old men by the goddess of love. Daniel appears in this addition as a youthful judge. Notwithstanding the paronomasia on Greek words in verses 54-55, 58-59, to which attention was called by Julius Africanus and Porphyry, it is by no means certain that the original was Greek. We may have here a free rendering of a Semitic original (see Bludau, *Die Alexandrinische Uebersetzung des Buches Daniel*, 1897).

Bel and the Dragon.—We have here two independent narratives, in both of which Daniel appears as the destroyer of heathenism. The latter had a much wider circulation than the former, and is most probably a Judaized form of the old Semitic myth of the destruction of the old dragon, which represents primeval chaos (see Ball, *Speaker's Apocr.* ii. 346-348; Gunkel, *Schopfung und Chaos*, 320-323). Most scholars maintain a Greek original, but this is by no means certain. Marshall (Hastings' *Bible Dict.* i. 268) argues for an Aramaic, and regards Gaster's Aramaic text (*Proceedings of the Society of Biblical Archæology*, 1894, pp. 280-290, 312-317; 1895, 75-94) as of primary value in this respect.

Additions to Esther.—These seven additions, written originally in Greek, were interpolated in the Greek translation of the *Book of Esther*. They consist of an edict of Haman, prayers of Mordecai and Esther, &c., and are so skilfully interpolated as to make no interruption in the history, though they occasionally contradict the canonical text. The Greek text appears in two widely-differing recensions. The one is supported by A B ℵ, and the other—a revision of the first—by codices 19, 93^a, 108^b. The latter is believed to have been the work of Lucian. For an account of the Latin and Syriac versions, the Targums, and the later Rabbinic literature connected with this subject, and other questions relating to these additions, see Fritzsche, *Exeget. Handbuch zu den Apok.* 1851, i. 67-108; Schurer^3, iii. 330-332; Fuller in *Speaker's Apocr.* i. 360-402; Ryssel, Kautzsch, *Apok. u. Pseud.* i. 193-212.

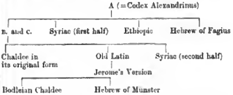
Epistle of Jeremy.—This letter (see *Ency. Brit.* iii. 405-406) purports to have been written by Jeremiah to the exiles who were already in Babylon or on the way thither. Recent research has not done much to elucidate the difficulties of this writing (see Fritzsche, *Handb. zu den Apok.* 1851; Gifford, *Speaker's Apocr.* ii. 286-303; Marshall, Hastings' *Bible Dict.* ii. 578-579).

2 *Maccabees.*—This book (see *Ency. Brit.* xv. 131) was written in the Pharisaic interest, probably by an Alexandrian Jew, although his work shows no trace of distinctively Alexandrian Judaism. Its aim is religious rather than historical, and where it comes into collision with 1 Macc. its evidence is generally set aside as worthless. On the other hand, it has undoubtedly a value of its own; and at times, in accord with Josephus, who was unacquainted with it (*cf.* iv.; vi. 2; xiii. 3-8; xiv. 1; see Grimm, *Exeget. Handbuch*, 1857, p. 13), it furnishes us, where 1 Macc. is silent, with historical materials of great worth. Geiger held that it was written as a deliberate polemic against 1 Macc., and Kosters (*Theol. Tijdschrift*, 1878, pp. 491-558) further argued that the so-called epitomizer was the actual author, and merely assumed the mask of Jason's name for controversial purposes. Although Kamphausen (*Apok. und Pseud.* i. 84) follows Kosters' lead, this view is preposterous. That a writer who wished to advocate the doctrines of Pharisaism should seek authentication by appealing to the work of an *African* Jew, unless such a work were actually in existence, would be without parallel in pseudepigraphic literature. Moreover, the eschatological details which appear in its narrative are just such as fit in with the eschatological systems of the 2nd century B.C., and were certainly not the current views when the epitomizer wrote between 50 B.C. and A.D. 1.

3 *Maccabees.*—This so-called book of Maccabees (see *Ency. Brit.* xv. 131) is a piece of fiction, recording an attempted massacre of the Jews under Ptolemy IV. Philopator, and based in part on an old legend preserved in Josephus, *Contra Apion*, ii. 5. The date is quite uncertain—sometime between 100 B.C. and A.D. 70 (see Grimm's *Exeget. Handbuch zu den Apok.* 1853, vol. iii.; Bissell, *Apocrypha*, 1880, pp. 615-637; Kautzsch's *Apok. u. Pseud.* 1900, i. 119-135; Fairweather in Hastings' *Bible Dict.* iii. 192-194).

Prayer of Manasseh.—Scholars are not yet agreed as to the original language of this penitential psalm. Most take it to have been written in Greek, and with these Fritzsche, Schürer, and Ryssel (Kautzsch, *Apok. u. Pseud.* i. 165-168) agree. On the other hand, Fürst, Ewald, Ball, and Budde argue for a Hebrew original. From the statements in 2 Chron. xxxiii. 12, 13, 18, 19, it follows that the chronicler found this prayer in Hebrew in his sources, *The History of the Kings of Israel* and *The History of the Seers*. Ewald regards the Greek as an actual translation of the lost Hebrew, but Ball more wisely takes it as a free rendering of a lost Haggadic narrative founded on the older document from which the chronicler drew his information. This view he supports by showing that there was once a considerable literature in circulation regarding Manasseh's later history. Fritzsche, Ball, and Ryssel agree in assigning this psalm to the Maccabean period. Its eschatology and doctrine "of divine forgiveness" may point to an earlier date. The best short account of the book is given by Ball (*Speaker's Apocrypha*, ii. 361-371); see also Porter in Hastings' *Bible Dictionary*, iii. 232-233.

Tobit.—To the excellent account of this book in *Ency. Brit.* xxiii. 427-428, it will not be necessary to make any great addition. Notwithstanding the arguments of Grätz (*Monatsschr. f. Gesch. des Judenthums*, 1879, pp. 145 *sqq.*, 385 *sqq.*, 433 *sqq.*, 509 *sqq.*, and of Rosenthal (*Vier apokryphische Bücher*, 1885, pp. 104-150), and of Fuller (Wace's *Apocrypha*, i. 1888, pp. 164-171) for a Hebrew original, the original language is generally, with Nöldeke (*Monatsberichte d. Berliner Akad.* 1879, 45 *sqq.*), taken to be Greek. The following table constructed by the last-named scholar will explain most briefly the relations of the many versions of this book:



The Hebrew texts published by Gaster, *Proceedings of* *the Society of Bibl. Archæology*, 1896, pp. 208-222, 259-271; 1897, pp. 27-38, have no more claim to represent the original than those above referred to.

Place and Date.—The book was most probably written in Egypt subsequently to the Maccabean rising and before the building of the Herodian temple 25 B.C.

On the literary connexion with the story of Achikar, see art. "Achiacharus" in *Ency. Bibl.*

(ii.) *Apocalyptic Literature.*

Slavonic Book of Enoch; or, the Book of the Secrets of Enoch.—This new fragment of the Enochic literature has only recently come to light through five MSS. discovered in Russia and Servia. Since about A.D. 500 it has been lost sight of. It is cited without acknowledgment in the *Book of Adam and Eve*, the *Apocalypses of Moses and Paul*, the *Sibylline Oracles*, the *Ascension of Isaiah*, the *Epistle of Barnabas*, and referred to by Origen and Irenæus (see Charles, *The Book of the Secrets of Enoch*, 1895, pp. xvii.-xxiv.). For Charles's *editio princeps* of this work, in 1895, Professor Morfill translated two of the best MSS., as well as Sokolov's text, which is founded on these and other MSS. In 1896 Bonwetsch issued his *Das slavische Henochbuch*, in which a German translation of the above two MSS. is given side by side, preceded by a short introduction. The main part of the book was written in Greek. This follows from the fact that in xxx. 13 it is said that Adam's name is derived from the four quarters of the earth: that is, from the initial letters of *ἀνατολή, δύσις, ἄρκτος, μεσημβρία*. This derivation is impossible in Semitic. Portions of the book, however, go back to a Semitic original, seeing that it is quoted in the *Test. XII. Patriarchs*, which was written in Semitic and belongs to the 2nd and 1st centuries B.C. The book in its present form was written in Egypt, for many of its speculations are characteristic of Philo and other Hellenistic writers: its account of the creation, xxv. *sq.*, betrays Egyptian elements, as well as its description of such creations as the Phœnixes and Chalkydries. Since this book quotes Ecclesiasticus, the Ethiopic Book of Enoch, and Wisdom (?), the *terminus a quo* cannot be earlier than 30 B.C., and the *terminus ad quem* must be assumed as earlier than A.D. 70, for the temple is still standing. The author was an orthodox Hellenistic Jew, who lived in Egypt. Thus he believed in sacrifices, xlii. 6, lix. 1, lxvi. 2; in the law, lii. 9, 10; and in an immortality of the blessed, in which the righteous should be clothed in "the raiment of God's glory," xxii. 8. The writer is an eclectic. Platonic (xxx. 16), Egyptian (xxv. 2), and Zend (lviii. 4-6) elements are incorporated in his system.

Oracles of Hystaspes.—See under N. T. Apocalypses.

Testament of Job.—This book was first printed from one MS. by Mai, *Script. Vet. Nov. Coll.* 1833, vii. i. 180, and translated into French in Migne's *Dict. des Apocryphes*, ii. 403. An excellent edition from two MSS. is given by M. R. James, *Apocrypha Anecdota*, ii. pp. lxxii.-cii. 104-137, who holds that the book in its present form was written by a Christian Jew in Egypt on the basis of a Hebrew Midrash on Job in the 2nd or 3rd century A.D. It is a cleverly-written work, but not of much value.

Testaments of the III Patriarchs.—For an account of these three Testaments (referred to in the *Apost. Const.* vi. 16), the first of which only is preserved in the Greek and is assigned by James to the 2nd century A.D., see that scholar's "Testament of Abraham," *Texts and Studies*, ii. 2, 1892, which appears in two recensions from six and three MSS. respectively, and Vassiliev's *Anecdota Græco-Byzantina*, 1893, pp. 292-308, from one MS. already used by James. This work was written in Egypt, according to James, and survives also in Slavonic, Roumanian, Ethiopic, and Arabic versions. It deals with Abraham's reluctance to die and the means by which his death was brought about. James holds that this book is referred to by Origen (*Hom. in Luc.* xxxv.), but this is denied by Schurer, who also questions its Jewish origin. With the exception of chaps. x.-xi., it is really a legend and not an apocalypse. An English translation of James's texts will be found in the *Ante-Nicene Christian Library*, Clark, 1897, pp. 185-201. The Testaments of Isaac and Jacob are still preserved in Arabic and Ethiopic (see James, *op. cit.* 140-161).

Sibylline Oracles.—We must here content ourselves in the main with referring the reader to *Ency. Brit.* ii. 177-179, xxii. 13-14, for the treatment of this subject. Not much has been done for the exegesis of this book of recent years. The most important contributions are those of Zahn, "Ueber Ursprung und religiösen Charakter der Sibyllinischen Bucher, iv.; v.; viii. 1-216; xii.; xiii." in the *Zeitschrift für kirchl. Wissensch. und kirchl. Leben*, 1886, pp. 32-45, 77-87; Hirsch, *Jewish Quarterly Review*, 1890, pp. 406-429; Deane, *Pseudepigrapha*, 1891, pp. 276-344; Harnack, *Gesch. der altchristl. Litteratur*, i. 762, 861-863; ii. 1, 581-589; Charles, *Ency. Biblica*, i. 245-250; Schurer^3, iii. 421-450; Blass in Kautzsch's *Apok. u. Pseud.* ii. 177-184. The best edition of the text is that of Rzach, *Oracula Sibyllina*, 1891. A Latin translation is appended to Alexandre's edition of the text and a German to that of Friedlieb. A translation in English blank verse has been made by Terry, *The Sibylline Oracles*, 1899. A literal prose rendering, with some exegetical notes and a critical introduction, is a desideratum.

(iii.) *Wisdom Literature.*

4 *Maccabees.*—This book (see *Ency. Brit.* xv. 131) bears a distinctly philosophic character. It has the form of a sermon of the synagogue; for, as Freudenthal points out, it presumes the presence of an audience (i. 1, xviii. 1). On the other hand, it was undoubtedly composed with a view to publication in Jewish circles (xviii. 1), for its abstruse style is unfitted for an ordinary congregation. The author is a Hellenistic Jew, but his conception of Judaism is strongly influenced by Stoicism. He teaches that the true Stoic ideal is possible only in Judaism: the passions are to be mastered, not exterminated, by reason; that is, by pious reason. Besides the Hellenistic view that only the soul can attain to a blessed immortality (xiii. 16, xv. 2, xvii. 18) this writer teaches that the martyrdom of the righteous atones for the sin of the people (vi. 29, xvii. 21). Eusebius's ascription of the book to Josephus (*H. E.* III. x. 6) is certainly wrong. The more recent literature on this book comprises Bensly's edition of the Syriac version of this book, *The Fourth Book of Maccabees . . . in Syriac, first edited . . . by the late R. L. Bensly, with an introduction and translations by Barnes*, 1895; Swete's *Old Testament in Greek*, 1894, iii. 729 *sqq.* Swete gives the text of A and variants from ℵ, the Cod. Ven., and certain fragments of Tischendorf. A German translation based on the above materials will be found in Kautzsch, *Apok. u. Pseud.* ii. 152-177.

5 *Maccabees.*—See *Ency. Brit.* xv. 131.

Wisdom of Solomon.—This pseudepigraph claims to have been written by King Solomon (vii.-ix., *cf.* ix. 7-8). The writer shows a close acquaintance with the canonical books bearing the name of Solomon. Siegfried (Kautzsch, *Apok. u. Pseud.* i. 476) is of opinion that this work is a deliberate polemic against the Epicurean-minded author of Ecclesiastes, and seeks to present Solomon as an example of Jewish piety. The book was written in Greek by an Alexandrian Jew. Though the Greek has many

Hebraisms (see Grimm, *Buch der Weisheit*, 1860, p. 5; Farrar, *Speaker's Apocrypha*, i. 404) the author displays a remarkable mastery in his use of it. Margoliouth has sought to show that it was composed not in Greek but in later Hebrew (*Journal of the Royal Asiatic Society*, 1890, pp. 263-297). But the strongly idiomatic character of its language, the philosophic cast of the thought, its Hellenistic theology and eschatology (Charles, *Eschatology: Hebrew, Jewish, and Christian*, 1899, pp. 251-258) prove incontestably its original composition in Greek (see Freudenthal's review of Margoliouth in the *Jewish Quarterly Review*, 1891, pp. 722-753). The author was a Jew well versed in Greek literature. Occasionally, it is true, he uses words in a non-Greek sense; but on the other hand he is so thoroughly at home in Greek that, like Philo, he ventures to coin new compound words and phrases. Furthermore, he was a student of Greek philosophy, especially of Plato and the Stoics, and uses familiarly the technical language of the schools (Grimm, *op. cit.* pp. 19-20; Farrar, *op. cit.* i. 407). The references to Egyptian animal-worship in xv. 18, 19, xvi. 1, 9, and the Hellenistic type of eschatology point to Egypt as the home of the author. The book is later than *Ecclesiasticus*, and probably earlier than Philo's writings. Hence in all likelihood it originated at some time within the years 150 B.C. and A.D. 10. The writer's object is to warn men against the folly of ungodliness, and particularly of idolatry. He takes his stand on the current dogmas of Platonic philosophy as to the essentially evil nature of matter and the pre-existence of the soul. Hence he teaches not the resurrection of the body but the immortality of the soul. This consummation can be attained only through the life of wisdom.

Texts, Versions, and Editions.—In *The Old Testament in Greek*, ii., Swete follows B, and gives in the notes the variants of ℵ, A and C. Fritzsche, in his *Libri Apocryphi V. T. Græce*, 1871, gives, in addition to the documents of the above MSS., those of Cod. Ven., the cursives and the versions; but his collation of B is untrustworthy. In *The Book of Wisdom*, 1881, Deane gives the Greek text (agreeing mostly with Fritzsche), the Latin version, and an English translation and commentary. Besides the Latin there are Syriac, Ethiopic, Armenian, and Arabic versions. Of these the Armenian is said to be the most faithful. For literature generally, see Schürer^{3}, iii. 382-383.

New Testament Apocryphal Literature.[1]

(i.) *Gospels*

Gospel according to the Egyptians.
Fayum Gospel Fragment.
Gospel according to the Hebrews.
Protevangel of James.
The Logia (?).
Gospel of Nicodemus.
Gospel of Peter.
Gospel of Thomas.
Gospel of the Twelve.

(ii.) *Acts and Teachings of the Apostles.*

Acts of Andrew.
Acts of John.
Acts of Paul.
Acts of Paul and Thecla.
Gnostic Acts of Peter.
Preaching of Peter.
Acts of Thomas.
Teaching of the Twelve Apostles.

(iii.) *Epistles.*

The Abgarus Epistles.
Epistle of Paul to the Laodiceans.
Third Epistle of Paul to the Corinthians, and the Epistle of the Corinthians to Paul.

(iv.) *Apocalypses.*

Greek Apocalypse of Baruch.
Testament of Hezekiah.
Oracles of Hystaspes.
Vision of Isaiah.
Apocalypse of Peter.

I.—*Gospels.*

Gospel according to the Egyptians.—This gospel is first mentioned by Clem. Alex. (*Strom.* iii. 63, 93), subsequently by Origen (*Hom. in Luc.* i.) and Epiphanius (*Hær.* lxii. 2), and a fragment is preserved in the so-called epistle of Clem. Rom. xii. It circulated among various heretical circles: amongst the Encratites (Clem. *Strom.* iii. 9), the Naassenes (Ps. Orig. *Philos.* v. 7), and the Sabellians (Epiph. *Hær.* lxii. 2). Only three or four fragments survive, see Lipsius (Smith and Wace, *Dict. of Christ. Biog.* ii. 712, 713); Zahn, *Gesch. d. NTlichen Kanons*, ii. 628-642; Preuschen, *Reste d. ausserkanonischen Evangelien*, 1901, p. 2, which show that it was a product of pantheistic Gnosticism. Lipsius and Zahn assign it to the middle of the 2nd century.

Fayum Gospel Fragment.—This small fragment contains two sayings of Christ and one of Peter, such as we find in the canonical gospels, Mt. xxvi. 31-34, Mk. xiv. 27-30. The papyrus, which is of the 3rd century, was discovered by Bickell among the Raines collection, who characterized it (*Z. f. kath. Theol.* 1885, pp. 498-504) as a fragment of one of the primitive gospels mentioned in Luke i. 1. On the other hand, it has been contended that it is merely a fragment of an early patriotic homily. (See Zahn, *op. cit.* ii. 780-790; Harnack, *Texte und Untersuchungen*, v. 4; Preuschen, *op. cit.* p. 19.)

Gospel according to the Hebrews.—This gospel was cited by Ignatius (*Ad Smyrnæos*, iii.) according to Jerome (*Viris illus.* 16, and *in Jes.* lib. xviii.), but this is declared to be untrustworthy by Zahn, *op. cit.* i. 921; ii. 701, 702. It was written in Aramaic in Hebrew letters, according to Jerome (*Adv. Pelag.* iii. 2), and translated by him into Greek and Latin. Both these translations are lost. A collection of the Greek and Latin fragments that have survived, mainly in Origen and Jerome, will be found in Hilgenfeld's *NT extra Canonem receptum*, Nicholson's *Gospel according to the Hebrews* (1879), Westcott's *Introd. to the Gospels*, and Zahn's *Gesch. des NTlichen Kanons*, ii. 642-723; Preuschen, *op. cit.* 5-11. This gospel was regarded by many in the first centuries as the Hebrew original of the canonical Matthew (Jerome, *in Matt.* xii. 13; *Adv. Pelag.* iii. 1). With the canonical gospel it agrees in some of its sayings; in others it is independent. It circulated among the Nazarenes in Syria, and was composed, according to Zahn (*op. cit.* ii. 722), between the years 135 and 150. Jerome identifies it with the *Gospel of the Twelve* (*Adv. Pelag.* iii. 2), and states that it was used by the Ebionites (*Comm. in Matt.* xii. 13). Zahn (*op. cit.* ii. 662, 724) contests both these statements. The former he traces to a mistaken interpretation of Origen (*Hom I. in Luc.*). Lipsius, on the other hand, accepts the statements of Jerome (Smith and Wace, *Dict. of Christian Biography*, ii. 709-712), and is of opinion that this gospel in the form in which it was known to Epiphanius, Jerome, and Origen, was "a recast of an older original," which, written originally in Aramaic, was nearly related to the Logia used by St Matthew and the Ebionitic writing used by St Luke, "which itself was only a later redaction of the Logia."

Protevangel of James.—This title was first given in the 16th century to a writing which is referred to as *The Book of James* (ἡ Βίβλος Ἰακώβου) by Origen (tom. xi. *in Matt.*). The narrative extends from the Conception of the Virgin to the Death of Zacharias. Lipsius shows that in the present form of the book there is side by side a strange "admixture of intimate knowledge and gross ignorance of Jewish thought and custom," and that accordingly we must "distinguish between an original Jewish Christian writing and a Gnostic recast of it." The former was known to Justin (*Dial.* 78, 101) and Clem. Alex. (*Strom.* vii. 16), and belongs at latest to the earliest years of the 2nd century. The Gnostic recast Lipsius dates about the middle of the 3rd century. From these two works arose independently the *Protevangel* in its present form and the Latin pseudo-Matthæus. The *Evangelium de Nativitate Mariæ* is a redaction of the latter. (See Lipsius in Smith's *Dict. of Christ. Biog.* ii. 701-703.) Zahn (*Gesch. Kanons*, i. 485, 499, 502, 504, 539; ii. 774-780) assigns the *Protevangel* to the first decade of the 2nd century.

---

[1] Only such works as were written or are supposed to have been written before A.D. 170 will be considered here.

The Logia (*q.v.*).—This name is given to the sayings contained in a papyrus leaf by its discoverers Grenfell and Hunt. They think the papyrus was probably written about A.D. 200. According to Harnack, it is an extract from the *Gospel of the Egyptians*.

Gospel of Nicodemus.—This title is first met with in the 13th century. It is used to designate an apocryphal writing entitled in the older MSS. "*ὑπομνήματα τοῦ Κυρίου ἡμῶν Ἰησοῦ Χριστοῦ πραχθέντα ἐπὶ Ποντίου Πιλάτου*:" also "Gesta Salvatoris Domini . . . inventa Theodosio magno imperatore in Ierusalem in prætorio Pontii Pilati in codicibus publicis." See Tischendorf, *Evangelia Apocrypha*^{2}, pp. 333-335. This work gives an account of the Passion (i.-xi.), the Resurrection (xii.-xvi.), and the *Descensus ad Inferos* (xvii.-xxvii.). Chapters i.-xvi. are extant in the Greek, Coptic, and two Armenian versions. The two Latin versions and a Byzantine recension of the Greek contain i.-xxvii. (see Tischendorf, *Evangelia Apocrypha*^{2}, pp. 210-458). All known texts go back to A.D. 425, if one may trust the reference to Theodosius. But this was only a revision, for as early as 376 Epiphanius (*Hær.* i. 1) presupposes the existence of a like text. In 325 Eusebius (*H. E.* ii. 2) was acquainted only with the heathen *Acts of Pilate*, and knew nothing of a Christian work. Tischendorf and Hofmann, however, find evidence of its existence in Justin's reference to the Ἄκτα Πιλάτου (*Apol.* i. 35, 48), and in Tertullian's mention of the *Acta Pilati* (*Apol.* 21), and on this evidence attribute our texts to the first half of the 2nd century. But these references have been denied by Scholten, Lipsius, and Lightfoot. Recently Schubert has sought to derive the elements which are found in the Petrine Gospel, but not in the canonical gospels, from the original *Acta Pilati*, while Zahn exactly reverses the relation of these two works. Rendel Harris (1899) advocated the view that the Gospel of Nicodemus is a prose version of the Gospel of Nicodemus, written in Homeric centones as early as the 2nd century. Lipsius and Dobschutz relegate the book to the 4th century. The question is not settled yet (see Lipsius in Smith's *Dict. of Christ. Biography*, ii. 708-709, and Dobschutz in Hastings' *Bible Dictionary*, iii. 541-547).

Gospel of Peter.—Before 1892 we had some knowledge of this gospel. Thus Serapion, bishop of Antioch (A.D. 190-203) found it in use in the church of Rhossus in Cilicia, and condemned it as Docetic (Eusebius, *H. E.* vi. 12. Again Origen (*In Matt.* tom. xvii. 10) says that it represented the brethren of Christ as His half-brothers. In 1885 a long fragment was discovered at Akhmim, and published by Bouriant in 1892, and subsequently by Lods, Robinson, Harnack, Zahn, Schubert, Swete. Harnack holds that Justin used this gospel, and hence assigns its composition to the beginning of the 2nd century; Sanday to 125, Zahn to 130, and Swete and Chase to 150.

Gospel of Thomas.—This gospel professes to give an account of our Lord's boyhood. It appears in two recensions. The more complete recension bears the title *Θωμᾶ Ἰσραηλίτου Φιλοσόφου ῥητὰ εἰς τὰ παιδικὰ τοῦ Κυρίου*, and treats of the period from the 7th to the 12th year (Tischendorf, *Evangelia Apocrypha*^{2}, 1876, 140-157). The more fragmentary recension gives the history of the childhood from the 5th to the 8th year, and is entitled *Σύγγραμμα τοῦ ἁγίου ἀποστόλου Θωμᾶ περὶ τῆς παιδικῆς ἀναστροφῆς τοῦ Κυρίου* (Tischendorf, *op. cit.* pp. 158-163). Two Latin translations have been published in this work by the same scholar—one on pp. 164-180, the other under the wrong title, *Pseudo-Matthæi Evangelium*, on pp. 93-112. A Syriac version, with an English translation, was published by Wright in 1875. This gospel was originally still more Docetic than it now is, according to Lipsius. Its present form is due to an orthodox revision which discarded, so far as possible, all Gnostic traces. Lipsius (Smith's *Dict. of Christ. Biog.* ii. 703) assigns it to the latter half of the 2nd century, but Zahn (*Gesch. Kan.* ii. 771), on good grounds, to the earlier half. The latter scholar shows that probably it was used by Justin (*Dial.* 88). At all events it circulated among the Marcosians (Ireneus, *Hær.* i. 20) and the Naasenes (Hippolytus, *Refut.* v. 7), and subsequently among the Manichæans, and is frequently quoted from Origen downwards (*Hom. I. in Luc.*). If the stichometry of Nicephorus is right, the existing form of the book is merely fragmentary compared with its original compass.

Gospel of the Twelve.—This gospel, which Origen knew (*Hom. I. in Luc.*), is not to be identified with the *Gospel according to the Hebrews* (see above), with Lipsius and others, who have sought to reconstruct the original gospel from the surviving fragments of these two distinct works. The only surviving fragments of the *Gospel of the Twelve* have been preserved by Epiphanius (*Hær.* xxx. 13-16, 22: see Preuschen, *op. cit.* 9-11). It began with an account of the baptism. It was used by the Ebionites, and was written, according to Zahn (*op. cit.* ii. 742), about A.D. 170.

II.—*Acts and Teachings of the Apostles.*

Acts of Andrew.—These acts (referred to by Euseb. *H. E.* iii. 25; Epiph. *Hær.* xlvii. 1, &c.) are ascribed to the authorship of Leucius. For a complete discusion of the various documents see Lipsius, *Apokryphen Apostelgeschichten*, i. 543-622; also James in Hastings' *Bible Dict.* i. 92-93. The best texts are in Bonnet's *Acta Apostolorum Apocrypha*, 1898, II. i. 1-127.

Acts of John.—These acts (*cf.* Eusebius, *H. E.* iii. 25; Epiph. *Hær.* xlvii. 1), which recount many marvellous acts of John, his exile, and death, spring from the same period and authorship as the *Acts of Peter.* For a discussion of this work see Zahn, *Gesch. Kanons*, ii. 856-865; Lipsius, *Apok. Apostelgesch.* i. 348-542. The only complete text is to be found in Bonnet, *Acta Apost. Apocrypha*, 1898, pp. 151-216. See James, *Anecdota*, ii. pp. i.-xxv., 1-25 (1897).

Acts of Paul.—These acts, which claim to have been written by Linus, are assigned by Zahn to the years 150-180. See *Gesch. Kanons*, ii. 865-891, and Lipsius, *Acta Apost. Apoc.* 1891; *Apok. Apostelgesch.* ii. 70 *sqq.*

Acts of Paul and Thecla.—These were written, according to Tertullian (*De Baptismo*, 17) by a presbyter of Asia, who was deposed from his office on account of his forgery. This, the earliest of Christian romances (probably before A.D. 150), recounts the adventures and sufferings of a virgin, Thecla of Iconium. Lipsius discovers Gnostic traits in the story, but these are denied by Zahn (*Gesch. Kanons*, ii. 902). See Lipsius, *op. cit.* ii. 424-467; Zahn (*op. cit.* ii. 892-910). The best text is that of Lipsius, *Acta Apost. Apoc.* 1891, i. 235-272. There are Syriac, Arabic, Ethiopic, and Slavonic versions.

Gnostic Acts of Peter.—These acts are first mentioned by Eusebius (*H. E.* iii. 3) by name, and first referred to by the African poet Commodian about A.D. 250. Yet Harnack assigns their composition to this period mainly on the ground that Hippolytus was not acquainted with them; but even were this assumption true, it would not prove the non-existence of the acts in question. The literary relationship between these acts and the Leucian *Acts of John* have been shown by Lipsius, Zahn, and James. According to Photius, moreover, the *Acts of Peter*, also, were composed by this same Leucius Charinus, who, according to Zahn (*Gesch. Kanons*, ii. 864), wrote about 160 (*op. cit.* p. 848). These acts deal with Peter's victorious conflict with Simon Magus, and his subsequent martyrdom at Rome under Nero. They are edited by Lipsius and Bonnet, *Acta Apostolorum Apocrypha*, 1891. See Zahn, *op. cit.* 832-855; James, *Apoc. Anec.* ii. pp. xxiv.-xxviii.; and Chase, in Hastings' *Bible Dict.* iii. 773-774.

Preaching of Peter.—This book (Πέτρου κήρυγμα) gave the substance of a series of discourses spoken by one person in the name of the apostles. Clement of Alexandria quotes it several times as a genuine record of Peter's teaching. Heracleon had previously used it (see Origen, *In Evang. Johann*, tom. xiii. 17). It is spoken unfavourably of by Origen (*De Prin.* Præf. 8). It was probably in the hands of Justin and Aristides. Hence Zahn gives its date as 90-100 at latest; Dobschütz, as 100-110; and Harnack, as 110-130. The extant fragments contain sayings of Jesus, and warnings against Judaism and Polytheism. They have been edited by Hilgenfeld: *Nov. Test. extra Can.* 1884, iv. 51-65, and by von Dobschütz, *Das Kerygma Petri*, 1893. Salmon (*Dict. Christ. Biog.* iv. 329-330) thinks that this work is part of a larger work, *A Preaching of Peter and a Preaching of Paul*, implied in a statement of Lactantius (*Inst. Div.* iv. 21); but this view is contested by Zahn, see *Gesch. Kanons*, ii. 820-834, particularly pp. 827-828; Chase, in Hastings' *Bible Dict.* iv. 776.

Acts of Thomas.—This is one of the earliest and most famous of the Gnostic acts. It has been but slightly tampered with by orthodox hands. The Greek and Latin texts were edited by Bonnet in 1883, the Greek also by James, *Apoc. Anec.* ii. 28-45, and the Syriac by Wright. Photius ascribes their composition to Leucius Charinus—therefore to the 2nd century, but Lipsius assigns it to the early decades of the 3rd. (See Lipsius, *Apokryphen Apostelgeschichten*, i. 225-347.)

Teaching of the Twelve Apostles (*q.v.*).—This important work was discovered by Philotheos Bryennios in Constantinople and published in 1883. Since that date it has been frequently edited. The bibliography can be found in Schaff's and in Harnack's editions. The book divides itself into three parts. The first (i.-vi.) contains a body of ethical instruction which is founded on a Jewish and probably pre-Christian document, which forms the basis also of the *Epistle of Barnabas*. The second part consists of vii.-xv., and treats of church ritual and discipline; and the third part is eschatological, and deals with the Second Advent. The book is variously dated by different scholars: Zahn assigns it to the years A.D. 80-120; Harnack to 120-165; Lightfoot and Funk to 80-100; Salmon to 120. See Salmon in *Dict. of Christ. Biog.* iv. 806-815.

III.—*Epistles.*

The Abgarus Epistles.—These epistles are found in Eusebius (*H. E.* i. 3), who translated them from the Syriac. They are two in number, and purport to be a petition of Abgar Uchomo, king of Edessa, to Christ to visit Edessa, and Christ's answer, promising after His ascension to send one of His disciples, who should "cure thee of thy disease, and give eternal life and peace to thee and all thy people." Lipsius thinks that these letters were manufactured about the year 200. (See *Dict. Christ. Biog.* iv. 878-881, with the literature there mentioned.) The above correspondence, which appears also in Syriac, is inwoven with the legend of Addai or Thaddæus. The best critical edition of the Greek text will be found in Lipsius, *Acta Apostolorum Apocrypha*, 1891, pp. 279-283.

Pauline Epistles to the Laodiceans and the Alexandrians.—The first of these is found only in Latin. This, according to Lightfoot (see Colossians^{8}, 272-298) and Zahn, is a translation from the Greek. Such an epistle is mentioned in the Muratorian canon. See Zahn, *op. cit.* ii. 566-585. The Epistle to the Alexandrians is mentioned only in the Muratorian canon. (See Zahn, ii. 586-592.)

Third Epistle of Paul to the Corinthians, and Epistle from the Corinthians to Paul.—These letters, which are still preserved in Armenian and Latin, are declared by Zahn to belong to the *Acts of Paul*. See *Gesch. Kanons*, ii. 592-611. On the Latin text see Carrière and Berger, *Correspondence apocr. de S. P. et des Corinthiens*, 1891; Vetter, *Der apokryphe 3 Korintherbrief*, 1894.

IV.—*Apocalypses.*

The five apocalypses in Tischendorf's *Apocalypses Apocryphæ*, 1866—*Apoc. Mosis* (which belongs to the Adam literature), *Apoc. Esræ*, *Apoc. Pauli*, *Apoc. Johannis*, *Dormitio Mariæ*—are of too late a date to be considered here, though they are in some respects valuable as containing ancient elements.

Greek Apocalypse of Baruch.—This work is referred to by Origen, *De Princip.* II. iii. 6: "Denique etiam Baruch prophetæ librum in assertionis hujus testimonium vocant, quod ibi de septem mundis vel cælis evidentius indicatur." This book survives in two forms in Slavonic and Greek. The former was edited by Bonwetsch in 1896, in the *Nachrichten von der königl. Ges. der Wiss. zu Gött.* pp. 91-101; the latter by James in 1897 in *Anecdota*, ii. 84-94, with an introduction (pp. li.-lxxi.). Neither work represents exactly the book of which Origen writes, for the Slavonic mentions only two heavens and the Greek only five. As the original work is based on the Syriac *Apocalypse of Baruch* and the *Rest of the Words of Baruch*, its composition falls between A.D. 136 and 200, if we accept the date assigned by Rendel Harris to the latter. A German translation of the Greek appears in Kautzsch's *Apok. u. Pseud.* ii. 448-457.

Testament of Hezekiah.—This writing is fragmentary, and has been preserved merely as a constituent of the *Ascension of Isaiah*. To it belongs iii. 13^{b}-iv. 18 of that book. It is found under the above name, Διαθήκη Ἐζεκίου, only in *Cedrenus* i. 120-121, who quotes partially iv. 12, 14, and refers to iv. 15-18. This evidence is supported by i. 2^{b}-5^{a} of the book, which describes the contents of *Hezekiah's Vision*, and which was inserted by the editor to prepare for the vision recounted in iii. 13^{b}-iv. 18. This vision is definitely said to be Hezekiah's in i. 2, 4, and in the *Greek Legend*, i. 2, which is built on the *Ascension of Isaiah*. The book may have in part a Semitic background, as Semiticisms are found in iii. 27. It was written between A.D. 88 and 100. The ground for the earlier date is furnished by the form of the Antichrist myth which it attests. We have here Beliar incarnated as Antichrist in the form of the dead Nero. The *terminus ad quem* is supplied by iv. 13, according to which few of the personal disciples of Christ were still living when the author wrote. Hence we may reasonably fix this limit at A.D. 100 at latest. See Charles, *Ascension of Isaiah*, 1900. (For versions, editions, &c., see section on "Martyrdom of Isaiah," and Charles, *Ascension of Isaiah*, pp. xvi., xix.-xxviii.). This work gives us a sketch of the Church at the close of the 1st century. It bewails the fewness of the prophets, the prevalence of heresies, and the sad declension in Christian character. It touches incidentally on the Guilds, whose object was to keep believers in readiness for the advent of Christ, but expecting actually to experience first the dreaded coming of the Antichrist.

Oracles of Hystaspes.—This eschatological work (Χρήσεις Ὑστάσπου: so named by the anonymous 5th-century writer in Buresch, *Klaros*, 1889, p. 95) is mentioned in conjunction with the Sibyllines by Justin (*Apol.* i. 20), Clement of Alexandria (*Strom.* vi. 5), and Lactantius (*Inst.* VII. xv. 19; xviii. 2-3). According to Lactantius, it prophesied the overthrow of Rome and the advent of Zeus to help the godly and destroy the wicked, but omitted all reference to the sending of the Son of God. According to Justin, it prophesied the destruction of the world by fire. According to the *Apocryph of Paul*, cited by Clement, Hystaspes foretold the conflict of the Messiah with many kings and His advent. Finally, an unknown 5th-century writer (see Buresch, *Klaros*, 1889, pp. 87-126) says that the *Oracles of Hystaspes* dealt with the incarnation of the Saviour. The work referred to in the last two writers has Christian elements, which were absent from it in Lactantius's copy. The lost oracles were therefore in all probability originally Jewish, and subsequently re-edited by a Christian.

Vision of Isaiah.—This writing has been preserved in its entirety in the *Ascension of Isaiah*, of which it constitutes chaps. vi.-xi. Before its incorporation in the latter work it circulated independently in Greek. Thus we have independent versions of these chapters in Latin and Slavonic. In the course of its incorporation in the *Ascension of Isaiah* it underwent certain changes to which we shall advert later. This work was written in Greek. In the 4th century two distinct recensions of this work already existed. The later of these, which contained 1 Cor. ii. 9 in xi. 34, was known to Jerome. This recension (now lost) was translated into Latin and Slavonic. The earlier recension is that which appears in the *Ascension of Isaiah*, of which large fragments are preserved in the *Greek Legend*. This recension, which preserves several passages which are either abbreviated or omitted by the later recension, was translated into Ethiopic and Latin. Most of the latter version is lost. The original work was used by Ignatius and the author of the *Actus Petri Vercellenses*, and in part preserved in Epiphanius. Accordingly we assign its composition to the close of the 1st century A.D. (For the various texts, the translation and interpretation, see Charles, *Ascension of Isaiah*, 1900.) The *Vision of Isaiah* is valuable for the knowledge it affords us of 1st-century beliefs in certain circles as to the doctrines of the Trinity, the Incarnation, the Resurrection, and the Seven Heavens. (For the bibliography, see section on "Martyrdom of Isaiah," p. 487.)

Apocalypse of Peter.—Till 1892 only some five or more fragments of this book were known to exist. These are preserved in Clem. Alex. and in Macarius Magnes (see Hilgenfeld, *N. T. extra Can.* iv. 74 *sqq.*; Zahn, *Gesch. Kanons*, ii. 818-819). It is mentioned in the Muratorian Canon, and according to Eusebius (*H. E.* vi. 14. 1) was commented on by Clement of Alexandria. In the fragment found at Akhmim there is a prediction of the last things, and a vision of the abode and blessedness of the righteous, and of the abode and torments of the wicked. For further information see the editions of James, Lods (1892), Harnack, and Dieterich (1893).

(R. H. C.)

Apolda, a town of Germany, in the grand-duchy of Saxe-Weimar, 9 miles by rail E. by N. from Weimar. Population (1885), 18,061; (1895), 20,798; (1900), 20,352.

Apostles, Teaching of the. See TEACHING OF THE APOSTLES.

Apostolical Constitutions.—The Apostolical Constitutions (Διαταγαὶ *or* Διατάξεις τῶν ἁγίων ἀποστόλων διὰ Κλήμεντος τοῦ Ῥωμαίων ἐπισκόπου τε καὶ πολίτου. Καθολικὴ διδασκαλία) are a collection of ecclesiastical regulations in eight books, the last of which concludes with the eighty-five *Canons of the Holy Apostles*. By their title the Constitutions profess to have been drawn up by the apostles, and to have been transmitted to the Church by Clement of Rome; sometimes the alleged authors are represented as speaking jointly, sometimes singly. From the first they have been very variously estimated; the *Canons*, as a rule, more highly than the rest of the work. For example, the Trullan Council of Constantinople (*quini-sextum*) A.D. 692 accepts the Canons as genuine by its second canon, but rejects the Constitutions on the ground that spurious matter had been introduced into them by heretics; and whilst the former were henceforward used freely in the East, only a few portions of the latter found their way into the Greek and oriental law-books. Again, Dionysius Exiguus (c. A.D. 500) translated fifty of the Canons into Latin, although under the title *Canones qui dicuntur Apostolorum*, and thus they passed into other Western collections; whilst the Constitutions as a whole remained unknown in the West until they were published in 1563 by the Jesuit Turrianus. At first received with enthusiasm, their authenticity soon came to be impugned; and their true significance was largely lost sight of as it began to be realized that they were not what they claimed to be. Vain attempts were still made to rehabilitate them, and they were, in general, more highly estimated in England than elsewhere. The most extravagant estimate of all was that of Whiston, who calls them "the most sacred standard of Christianity, equal in authority to the Gospels themselves, and superior in authority to the epistles of single apostles, some parts of them being our Saviour's own original laws delivered to the apostles, and the other parts the public acts of the apostles" (Historical preface to *Primitive Christianity Revived*, pp. 85-86). Others, however, realized their composite character from the first, and by degrees some of the component documents became known. Bishop Pearson was able to say that "the eight books of the Apostolic Constitutions have been after Epiphanius's time compiled and patched together out of the *didascaliae* or doctrines which went under the names of the holy apostles and their disciples or successors" (*Vind. Ign.* i. cap. 5); whilst a greater scholar still, Archbishop Usher, had already gone much further, and concluded, forestalling the results of modern critical methods, that their compiler was none other than the compiler of the spurious Ignatian epistles (*Epp. Polyc. et Ign.* p. lxiii. f., Oxon. 1644). The Apostolical Constitutions, then, are spurious, and they are one of a long series of documents of like character. But we have not really gauged their significance by saying that they are spurious. They are the last stage and climax of a gradual process of compilation and crystallization, so to speak, of unwritten church custom; and a short account of this process will show their real importance and value.

These documents are the outcome of a tendency which is found in every society, religious or secular, at some point in its history. The society begins by living in accordance with its fundamental principles. By degrees these translate themselves into appropriate action. Difficulties are faced and solved as they arise; and when similar circumstances recur they will tend to be met in the same way. Thus there grows up by degrees a body of what may be called customary law. Plainly, there is no particular point of time at which this customary law can be said to have begun. To all appearance it was there from the first in solution and gradually crystallizes out; and yet it is being continually modified as time goes on. Moreover, the time comes when

Origin and real nature.

the attempt is made, either by private individuals or by the society itself, to put this "customary law" into writing. Now when this is done, two tendencies will at once show themselves. (*a*) This "customary law" will at once become more definite: the very fact of putting it into writing will involve an effort after logical completeness. There will be a tendency on the part of the writer to fill up gaps; to state local customs as if they obtained universally; to introduce his personal equation, and to add to that which is the custom that which, in his opinion, *ought* to be. (*b*) There will be a strong tendency to fortify that which has been written with great names, especially in days when there is no very clear notion of literary property. This is done, not always with any deliberate consciousness of fraud (although it must be clearly recognized that truth is not one of the "natural virtues," and that the sense of the obligations of truthfulness was far from strong), but rather to emphasize the importance of what was written, and the fact that it was no new invention of the writer's. In a non-literary age fame gathers about great names; and that which, *ex hypothesi*, has gone on since the beginning of things is naturally attributed to the founders of the society. Then come interpolations to make this ascription more probable, and the prefixing of a title, then or subsequently, which states it as a fact. This is precisely the way in which the Apostolical Constitutions and other kindred documents have come into being. They are attempts, made in various places and at different times, to put into writing the order and discipline and character of the Church; in part for private instruction and edification, but in part also with a view to actual use; frequently even with an actual reference to particular circumstances. In this lies their importance, to a degree which has scarcely been adequately realized yet. They contain evidence of the utmost value as to the order of the Church in early days; evidence, however, which needs to be sifted with the greatest care, since the personal preferences of the writer and the customs of the local church to which he belongs are continually mixed up with things which have a wider prevalence. It is only by careful investigation, by the method of comparisons, that these elements can be disentangled; but as the number of documents of this class known to us is continually increasing, their value increases even more than proportionately. And whilst their local and fugitive character must be fully recognized and allowed for, is it unjustifiable to set them aside or leave them out of account as heretical, and therefore negligible.

Other collections.

It will be sufficient here to mention shortly the chief collections of this kind which came into existence during the first four centuries; generally as the work of private individuals, and having, at any rate, no more than a local authority of some kind. (*a*) The earliest known to us is the *Didache* or *Teaching of the Twelve Apostles*, itself compiled from earlier materials, and dating from, at any rate, the earlier half of the 2nd century [TEACHING OF THE APOSTLES]. (*b*) The Apostolic Church Order (*apostolische Kirchenordnung* of German writers); "Ecclesiastical Canons of the Holy Apostles" of one MS.; *Sententiae Apostolorum* of Pitra: of the 3rd century, and emanating probably from Upper Egypt. Its earlier part, cc. 1-14, depends upon the *Didache*, and the rest of it is a book of discipline in which Harnack has attempted to distinguish two older fragments of church law (*Texte u. Unters.* ii. 5). (*c*) The so-called *Canones Hippolyti*, probably Egyptian or Roman and of the beginning of the 3rd century. It will be observed that these make no claim to apostolic authorship; but otherwise their origin is like that of the rest, unless indeed, as has been suggested, they represent the work of an actual Roman synod. (*d*) The so-called *Egyptian Church Order*, now extant only in a fragmentary Latin version recently published by Hanler, and as part of two larger collections; the former (sometimes called the Egyptian Church Ordinances) being cc. 31-62 of the Sahidic *Ecclesiastical Canons*, and the latter being stat. 21-71 of the Ethiopic *Statutes of the Apostles*. It is apparently of the end of the 3rd century or beginning of the 4th. (*e*) The recently-discovered *Testament of the Lord*, which is somewhat later in date, and likewise depends upon the *Canones Hippolyti* [TESTAMENT OF THE LORD]. (*f*) The so-called *Canons of Basil*. [On the relations between the four last-named, see CANONS OF HIPPOLYTUS.] (*g*) The *Didascalia Apostolorum*, originally written in Greek, but known through a Syriac version and a fragmentary Latin one published by Hauler. It is of the middle of the 3rd century—in fact, a passage in the Latin translation seems to give us the date A.D. 254. It emanates from Palestine or Syria, and is independent of the documents already mentioned; and upon it, as we shall see, the *Constitutions* themselves very largely depend. (*h*) A number of shorter fragments, published by Lagarde, Pitra, and others. (*i*) *The Apostolical Constitutions.*—At a later date various collections were made of the documents above mentioned, or some of them, to serve as law-books in different churches—*e.g.*, the Syrian Octateuch, the Egyptian Heptateuch, and the Ethiopic Sīnōdōs. These, however, stand on an entirely different footing, since they are simply collections of existing documents, and no attempt is made to claim apostolic authorship for them.

Contents

The Constitutions themselves fall into three main divisions. (i.) The first of these consists of books i.-vi., and throughout runs parallel to the *Didascalia*. Bickell, indeed, held that this latter was an abbreviated form of books i.-vi.; but it is now agreed on all hands that the Constitutions are based on the *Didascalia* and not *vice versâ*. (ii.) Then follows book vii., the first thirty-one chapters of which are an adaptation of the *Didache*, whilst the rest contain various liturgical forms of which the origin is still uncertain, though it has been acutely suggested by Achelis, and with great probability, that they originated in the schismatical congregation of Lucian at Antioch. (iii.) Book viii. is more composite, and falls into three parts. The first two chapters, περὶ χαρισμάτων, may be based upon a lost work of St Hippolytus, otherwise known only by a reference to it in the preface of the Latin version of the *Egyptian Church Order*; and an examination shows that this is highly probable. The next section, cc. 3-27, περὶ χειροτονιῶν, and cc. 28-46, περὶ κανόνων, is twofold, and is evidently that upon which the writer sets most store. The apostles no longer speak jointly, but one by one in an apostolic council, and the section closes with a joint decree of them all. They speak of the ordination of bishops (the so-called Clementine Liturgy is that which is directed to be used at the consecration of a bishop, cc. 5-15), of presbyters, deacons, deaconesses, sub-deacons, and lectors, and then pass on to confessors, virgins, widows, and exorcists; after which follows a series of canons on various subjects, and liturgical formulæ. With regard to this section, all that can be said is that it includes materials which are also to be found elsewhere—in the *Egyptian Church Order* and other documents already spoken of—and that the precise relation between them is at present not determined. The third section consists of the Apostolic Canons already referred to, the last and most significant of which places the Constitutions and the two epistles of Clement in the canon of Scripture, and omits the Apocalypse. They are derived in part from the preceding Constitutions, in part from the canons of the councils of Antioch, 341, Nicaea, 325, and possibly Laodicaea.

A comparison of the Constitutions with the material upon which they are based will illustrate the compiler's method. (*a*) To begin with the *Didascalia*. It is unmethodical and badly digested, homiletical in style, and abounding in Biblical quotations. There is no precise arrangement; but the subjects, following a general introduction, are the bishop and his duties, penance, the administration of the offerings, the settlement of disputes, the divine service, the order of widows, deacons and deaconesses, the poor, behaviour in persecution, and so forth. The compiler of the Constitutions finds here material after his own heart. He is even more discursive and more homiletical in style: he adds fresh citations of the Scriptures, and additional explanations and moral reflexions; and all this with so little judgment that he often leaves confusion worse confounded (*e.g.*, in ii. 57, where, upon a symbolical description of the Church as a sheepfold, he has superimposed the further symbolism of a ship). (*b*) Passing on to books vii. and viii., we observe that the compiler's method of necessity changes with his new material. In the former book he still makes large additions and alterations, but there is less scope for his prolixity than before; and in the latter, where he is no longer dealing with generalities, but making actual definitions, the Constitutions of necessity become more precise and statutory in form. Throughout he adopts and adapts the language of his sources as far as possible, "only pruning in the most pressing cases," but towards the end he cannot avoid making larger alterations from time to time. And his alterations throughout are not made aimlessly. Where he finds things which would obviously clash with the customs of his own day, he unhesitatingly modifies them. An account of the Passion, with a curiously perverted chronology, the object of which was to justify the length of the Passion-tide fast, is entirely revised for this reason (v. 14); the direction to observe Easter according to the Jewish computation is changed into the exact contrary for the same reason (v. 17); and where his archetype lapses into speaking of a lull in persecution he naively informs us that the Romans have now given up persecuting and have adopted Christianity (vi. 26), forgetting altogether that he is speaking in the character of the apostles. Above all, he both magnifies the office of the Christian ministry as a whole and alters what is said of it in detail (for example, the deaconess loses rank not a little), to make it agree with the circumstances of his day in general, and with his own ideas of fitness in particular. It is here that his evidence is at once most valuable and needing to be used with the greatest care. To give one striking example of the value of these documents. The *Canones Hippolyti* (vi. 43) provide that one who has been a confessor for the faith may be received as a presbyter by virtue of his confessorship and not by the laying on of the bishop's hands; but if he be chosen a bishop, he is to be ordained. This provision passes on into the Egyptian *Ecclesiastical Canons* and other kindred documents, and even into the *Testamentum Domini*. But the corresponding passage in the Apostolical Constitutions (viii. 23) entirely reverses it: "A confessor is not ordained, for he is so by choice and patience, and is worthy of great honour. . . . But if there be occasion, he is to be ordained either a bishop, priest, or deacon. But if any one of the confessors who is not ordained snatches to himself any such dignity upon account of his confession, let the same person be deprived and rejected; for he is not in such an office, since he has denied the constitution of Christ, and is worse than an infidel."

Authorship, place, and date.

Who, then, is the author of the Constitutions, and what can be inferred with regard to him? (i.) By separating off the sources which he used from his own additions to them, it at once becomes clear that the latter are the work of one man: the style is unmistakable, and the method of working is the same throughout. The compiler of books i.-vi. is also the compiler of books vii., viii. (ii.) As to his theological position, different views have been held. Funk suggests Apollinarianism, which is the refuge of the destitute; and Achelis inclines in the same direction. But the affinities of the author are quite otherwise, the most pronounced of them being a strong subordinationist tendency, denial of a human soul to Christ, and the like, which suggest not indeed Arianism but an inclination towards Arianism. Above all, his polemic is directed against the dying heresies of the 3rd century; and he writes with an absence of constraint which is not the language of one who lives amidst violent controversies or who is conscious of being in a minority. All this points to the position of a "conservative" or semi-Arian of the East, one who belongs, perhaps, to the circle of Lucian of Antioch and writes before the time of Julian. It is hard to think of any other time or circumstances in which a man could write like this. (iii.) The indications of *time* have been held to point to a different conclusion. On the one hand, the fact that the attempt to rebuild the temple by Julian in 363 is not mentioned in vi. 24 points to an earlier date; and the fact the κοπιᾶται are not mentioned amongst the church officers points in the same direction, for elsewhere they are first mentioned in a rescript of Constantius in A.D. 357. On the other hand, in the cycle of feasts occur the names of several which are probably of later date—*e.g.*, Christmas and St Stephen, which were introduced at Antioch c. A.D. 378 and 379 respectively. Again, Epiphanius (c. A.D. 374) appears to be unacquainted with it; he still quotes from the *Didascalia*, and elaborately explains it away where it is contrary to the usages of his own day. But as regards the former point, it is possible that the Apostolical Constitutions actually gave rise to these festivals; or, on the other hand, that the two passages were subsequently introduced either by the writer himself or by some other hand, when the last book of the Constitutions was being used as a law-book. And as regards the latter, the fact that Epiphanius does not use the Constitutions is no proof that they had not yet been compiled. (iv.) As to the region of composition there is no real doubt. It was clearly the East, Syria or Palestine. Many indications are against the latter, and Syria is strongly suggested by the use of the Syro-Macedonian calendar. Moreover, the writer represents the Roman Clement as the channel of communication between the apostles and the Church. This fact both supplies him with the name by which he is commonly known, Pseudo-Clement, and also furnishes corroboration of his Syrian birth; since the other spurious writings bearing the name of Clement, the *Homilies* and *Recognitions*, are likewise of Syrian origin. Moreover, the spurious Ignatian epistles, which are also Syrian, depend throughout upon the Constitutions. (v.) But this is not all. It was long ago noticed that Pseudo-Clement bears a very close resemblance to Pseudo-Ignatius. Usher, as we have seen, identified them, and modern criticism accepts this identification as a fact (Lagarde, Harnack, Funk, Brightman). Lightfoot, indeed, still hesitated (*Ap. Fathers* II. i. 266 n.) on the ground that Pseudo-Ignatius occasionally misunderstands the Constitutions, that the two writings give the Roman succession differently, and that Pseudo-Clement shows no knowledge of the Christological controversies of Nicaea. But as regards the first of these, it is rather a case of condensed citation than of misinterpretation; the second is explained by the writer's carelessness as shown in other passages, and all are solved if a considerable interval of time elapsed between the compilation of the Constitutions and the spurious Ignatian epistles.

It is clear then that the compiler was a Syrian, and that he also wrote the spurious Ignatian epistles; he was likewise probably a semi-Arian of the school of Lucian of Antioch. His date is given by Harnack as A.D. 340-360, with a leaning to 340-343; by Lightfoot as the latter half of the 4th century; by Brightman, 370-380; and by Funk as the beginning of the 5th century. The present writer holds to the first-named of these—*i.e.*, 340-360.

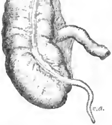
AUTHORITIES.—UELTZEN. *Constitutiones Apostolicae.* Suerini, 1853.—LAGARDE. *Didascalia Apostolorum Syriace.* Lips. 1854.—BUNSEN. *Christianity and Mankind*, vi. (= *Analecta ante-nicaena* ii.) Lond. 1854. An unsatisfactory attempt to reconstruct the original Greek text of the *Didascalia* by means of the Syriac text and the Apostolical Constitutions.—LAGARDE. *Constitutiones Apostolorum.* Lips. et Lond. 1862.—J. B. PITRA. *Juris Ecclesiastici Graecorum Historia et Monumenta*, i. Romae, 1864.—HAULER. *Didascaliae Apostolorum Fragmenta Veronensia Latina.* Lipsiae, 1900.—See also BICKELL. *Geschichte des Kirchenrechts*, i. Giessen, 1843.—F. X. FUNK. *Die apostolischen Konstitutionen.* Rottenb. 1891.—HARNACK. *Geschichte d. altchristl. Litteratur*, i. 515 ff. Leipz. 1893.—BRIGHTMAN. *Liturgies Eastern and Western*, I. xvii. ff. Oxford, 1896.—ACHELIS in HAUCK, *Real-Enkyklopädie*, i. 734 f., Art. "Apostolische Konstitutionen und Kanones." Leipz. 1896

(W. E. Co.)

Appalachian Mountains. See AMERICA, NORTH.

Appendicitis.—In medical nomenclature the termination "itis" is used to signify inflammation, and is arbitrarily tacked on to the end of any word, whether of Greek or Latin origin. On this principle "appendicitis" has been coined to designate inflammation connected with that part of the intestine which is known as the "appendix." There is no reason to suppose that the affection is more common than it used to be; but it is now better understood and more frequently recognized, and the development of modern abdominal surgery has brought it into prominence. It was formerly included under the term "perityphlitis"—that is, inflammation connected with the "cæcum," a portion of the large intestine,—and some authorities still prefer that term as more scientifically accurate; but it is now generally recognized that in the vast majority of cases the inflammation begins in the appendix, not in the intestine proper. From the appendix it extends to the surrounding peritoneum and sets up a localized peritonitis, which in the worst cases may become general.

The appendix is a narrow tube, normally about the size of a goose quill, and from 1 inch to 5 or 6 inches in length. The average length is 3 inches. It terminates in a blunt point, and from its worm-like shape is called the *appendix vermiformis.* It is an appendage of the large intestine, into which it opens. It is not known to perform any functions, and is regarded as the degenerate relic, surviving in man and other mammals, of an earlier form of intestine. Owing to its shape, character, and situation the appendix is frequently the seat of morbid changes. They have been observed in one-third of a number of bodies examined *post mortem.* Inflammation is set up in various ways. Foreign bodies passing down the intestinal canal may find their way into the appendix and lodge there. This was formerly believed to be the chief cause of mischief; hence the warning, familiar to every child, against the danger of swallowing cherry stones and other small, hard objects. Extended knowledge, however, has shown that such foreign bodies are only present in a small minority of cases. More frequently the tube is found blocked by hardened fæces or undigested particles of food, such as nuts, cheese, fibrous vegetable matter, and other imperfectly masticated substances. Sometimes calcareous concretions are formed round a nucleus furnished by some small body. Inflammation may occur, however, without any of these things. The tube may be twisted or otherwise strangulated, leading to gangrene; or the orifice may be closed in a similar manner, so that the tube becomes greatly distended with mucus, which can find no outlet; or ulceration of tuberculous origin may occur. In all cases inflammation started in the appendix is liable to spread to the surrounding membranes, and herein lies the gravity of the affection.



LARGE INTESTINE SHOWING VERMIFORM APPENDIX (v.a.).

For clinical purposes several varieties of appendicitis may conveniently be distinguished according to the degree and course of the inflammation: (1) simple inflammation, commonly called "catarrhal"; (2) ulcerative; (3) perforative; (4) relapsing; (5) chronic.

The symptoms vary accordingly within wide limits, ranging from slight pain and sickness, which pass off in a day or two, to an exceedingly violent illness, which may cause death in a few hours. (1) Simple inflammation. In a well-defined case the onset is sudden. Pain is felt in the belly, low down on the right side (the right iliac fossa), or across the front; it is often described as "radiating." There is some fever, the temperature rising to 101° or 102° F., with constipation, nausea, and very likely vomiting. The abdomen is tender to pressure, and the tenderness may be referred to a particular spot. Some swelling may also be made out. The attack lasts for two, three, or four days, and then subsides. There are, however, other cases less well defined, in which the mischief pursues a latent course, producing little more than a vague abdominal uneasiness, until it suddenly advances into a more violent stage. (2) The illness assumes a more acute form, and all the symptoms are more severe. There may be an initial rigor; the temperature rises to 104° or higher, with great prostration, severe pain, and complete loss of appetite. An unpleasant taste in the mouth is often observed; vomiting may persist and become fæcal. Abdominal tenderness is more marked and general, and swelling more obvious. The patient lies with legs drawn up, so as to ease pressure on the abdomen and lessen pain. The attack may subside or go on to the suppuration and the formation of an abscess. (3) If the abscess break into the general abdominal cavity, there is sudden and violent pain with collapse. The condition is one of extreme gravity. Death usually follows within forty-eight hours, and recovery is very rare. (4) Some persons are subject to recurrent attacks of appendicitis, and to this variety of the disease the term "relapsing" is applied. Such attacks do not differ in character from those previously described. They are no doubt due to some standing condition of the appendix coupled with imperfect performance of the digestive functions, but they only occur at intervals, and between the attacks the patient is well. (5) The chronic form of appendicitis differs from the relapsing in that the patient is never well, but always suffers from more or less uneasiness, which is liable to develop into an acute attack.

With regard to treatment it is obvious that, however mild an attack may be, an affection liable to assume such grave forms is not to be trifled with and demands early medical assistance. In the milder cases the measures indicated are rest in bed, hot fomentations or poultices to the abdomen, and opiates to relieve pain and keep the intestine quiet. Leeches over the abdomen give much relief. Food should be hot, fluid, and given in small quantities. Ice and milk are not suitable. Solid food should not be given until fever has abated and distinct improvement set in. Great care should be exercised in the administration of aperients, and as this is a matter which patients or their friends are apt to take into their own hands it is necessary to give an emphatic warning against the practice so long as the symptoms described are present. The safest course is to eschew aperients altogether. In cases of moderate severity it may be desirable to open the bowels, but this is best accomplished by enemata.

In the majority of cases the foregoing measures will suffice, but when the attack pursues an unfavourable course the question of operative interference arises. There is a considerable difference of opinion among surgeons on the point. Some advocate early operation in all cases; others, of a more conservative tendency, prefer to give the inflammation an opportunity of subsiding without interference, and hold that in uncomplicated cases it only becomes necessary when the symptoms persist after the fifth day. Perhaps the soundest rule is to operate in all doubtful cases. Removal of the appendix in persons liable to recurrent attacks has been practised with great success, and may be regarded as one of the triumphs of modern surgery. The danger of relapse may, however, be guarded against by less drastic means. Persons who have had an attack should attend to their mastication and be careful about diet. In particular, they should avoid indigestible substances, and counteract any tendency to constipation. Exercise and abdominal massage are recommended, but the advisability of the latter is open to question.

The prognosis in appendicitis is generally favourable. The "case mortality" is believed to be about 5 per cent., but in the graver forms it is very much higher. Men are said to be more liable to attack than women. It has been suggested that some constitutional states, such as a rheumatic or gouty tendency, predispose to appendicitis, but the theory is not supported by any substantial evidence.

Affections with which appendicitis is liable to be confounded are acute intestinal obstruction, typhoid fever, renal and gall-stone colic. The first of these resembles it most closely, and diagnosis is sometimes very difficult. In typhoid fever the characteristic temperature, the general condition of the patient, and the presence of delirium are differentiating signs of importance; in renal and gall-stone colic the situation and more paroxysmal character of the pain are usually distinctive. (See also SURGERY.) (A. SL.)

Appenzell, one of the Swiss cantons, since 1597 divided into the two half cantons of Ausser Rhoden and Inner Rhoden, the joint total area of which is 161·8 sq. miles. Of this Ausser Rhoden claims 100½ sq. miles, 97·8 sq. miles being classed as "productive," forests covering 18·1 sq. miles, and vineyards ·01 sq. mile, while of the 2·7 "unproductive" sq. miles, eternal snows cover 0·3 sq. mile. Inner Rhoden has an area of 61·3 sq. miles, of which 56·7 sq. miles are classed as "productive," forests covering 2·7 sq. miles, while of the "unproductive" 4·6 sq. miles ·38 is occupied by eternal snows. The population of Ausser Rhoden was in 1880, 51,953; in 1888, 54,109; and in 1900, 55,284, or 551 per sq. mile; of Inner Rhoden the population was in 1880, 12,874; in 1888, 12,874; and in 1900, 13,486, or 220 per sq. mile. The rate of density in the former is only exceeded in Switzerland by Geneva, and Basel Stadt (Bâle Ville). In 1900 there were in Ausser Rhoden but 580 Italian-speaking (in Inner Rhoden, 78) and 86 (in Inner Rhoden only 4) French-speaking inhabitants, the rest being German-speaking. The religious statistics are as follows (1900), Ausser Rhoden—Protestants, 49,741; Romanists, 5501; Jews, 31; Inner Rhoden—Protestants, 830; Romanists, 12,653.

The loftiest point in the canton is the Säntis, 8216 feet, now crowned by an observatory and an inn. The political capital of Ausser Rhoden is Herisau, while that of Inner Rhoden is Appenzell. Both halves of the canton still preserve their primitive democratic assemblies. In 1897, the state revenue of Ausser Rhoden was 640,162 francs (an increase of 100 per cent. since 1885), and the state expenditure 613,337 francs (an increase of 61 per cent. since 1885), while in 1898 the surplus was 18,490 francs; the state debt in 1897 was nil. In 1897, Inner Rhoden had a state revenue of 181,932 francs (an increase of nearly 72 per cent. since 1885), and a state expenditure of 165,409 francs (an increase of 64 per cent. since 1885), but in 1898 there was a deficit of 24,544 francs; in 1897 there was no public debt. In 1899, the mountain pastures or "alps" of Inner Rhoden were 168 in number, and capable of supporting 4008 cows, while the capital value was put at 2,682,955 francs; accurate statistics have not yet been published as regards Ausser Rhoden.

Appenzell, the chief town of the above canton, situated in Inner Rhoden. The two convents are both Capuchin, that of the men dating from 1588, and that of the women being a few years later in date. The "Teufel" flag was captured from the Tyrolese in 1406 at Imst, near Landeck. In 1888, the population of Appenzell (which is rather a large village than a town) was 4472, and in 1899 was put at 4369.

REFERENCES. — *Appenzellische Jahrbücher.* 3 series from 1854. Trogen.—EBEL. *Schilderung d. Gebirgsvölker d. Schweiz.* Leipzig, vol. i. (1798) describes App.—KOBELT. *Die Alpwirthschaft im Kant. App.*, Inner Rhoden. Soleure, 1899.—RICHMAN. *Appenzell.* London, 1895.—ZELLWEGER. *Geschichte d. App. Volkes* (to 1597). 6 vols. in 11 parts. Trogen, 1830-38. *Der Kant. App.* Trogen, 1867. (W. A. B. C.)

Appleby, a municipal borough (1885), market-town and county town of Westmoreland, England, on the Eden, 13 miles S.E. of Penrith, in the Appleby parliamentary division of the county. Station on the Midland Railway. The bridge over the Eden has been rebuilt. Two Wesleyan chapels and new grammar school buildings are modern erections. Area, 1855 acres; population (1881), 1853; (1891), 1776; (1901), 1764.

Appleton, a city of Wisconsin, U.S.A., the capital of Outagamie county, situated in 44° 16′ N. lat. and 88° 24′ W. long., at an altitude of 718 feet, in the eastern part of the state, at the Grand Chute on Lower Fox river, which supplies excellent water-power for lumber and paper manufactures. The plan of the city is regular, and it is divided into six wards. It is entered by the Chicago and North-western and the Chicago, Milwaukee, and St Paul railways. It is the seat of Lawrence University. The city received its name from Samuel Appleton, who was one of its founders, and a leading spirit in the organization of Lawrence University. Population (1880), 8005; (1890), 11,869; (1900), 15,085.

Appomattox, a village of Appomattox county, Virginia, U.S.A., formerly the capital. It is situated in southern Virginia, on the Norfolk and Western railway. It is noted as the scene of the surrender of the army of northern Virginia under General Lee to the Federal forces under Grant on 9th April 1865.

Apportionment.—The term "apportionment" is used in law in a variety of senses:—(i.) Sometimes it is employed, roughly and with no technical meaning, to indicate the distribution of a benefit (*e.g.*, salvage), or the incidence of a duty (*e.g.*, obligations as to the maintenance of highways); (ii.) In its strict legal interpretation it falls into two classes, "apportionment in respect of estate" and "apportionment in respect of time." Where a lessee is evicted from, or surrenders, or forfeits possession of part of the property leased to him, he becomes liable at common law to pay only a rent apportioned to the value of the interest which he still retains. So where the person entitled to the reversion of an estate assigns part of it, the right to an apportioned part of the rent incident to the whole reversion passes to his assignee. In each of these cases there is said to be "apportionment in respect of estate." Apportionment of this description may be brought about not only, as in the cases above noted, by the act of the parties, but also by operation of law, or by the "act of God" (as, for instance, where part of an estate is submerged by the encroachments of the sea); and to the same category belongs the apportionment which takes place under various statutes (*e.g.*, the Lands Clauses Act, 1845), when land is required for public purposes. Under the Apportionment Act, 1870, rents, annuities, dividends, and other payments at fixed periods, are to be considered as accruing from day to day, and to be apportionable accordingly. This is "apportionment in respect of time." The cases to which it applies are mainly cases of either (*a*) apportionment of rent due under leases where at a time between the dates fixed for payment the lessor or lessee dies, or some other alteration in the position of parties occurs; or (*b*) apportionment of income between the representatives of a limited owner and the remainder-man when the limited interest determines at a time between the date when such income became due. (A. W. R.)

Apulia, Italian *Puglia*, a territorial division of Italy, stretching from Monte Gargano to the extremity of the "heel," and embracing the provinces of Bari, Foggia, and Lecce, with an area of 7376 sq. miles and a population of 1,589,064 (1881), and 1,929,723 (1899). It is a treeless plain, growing corn and feeding sheep, the principal wealth of the inhabitants. The products next in importance are oats, barley, olives, wine, lemons, oranges, tobacco, and figs. Salt, limestone, and other building stone are extracted. Wool is a source of wealth. Distilleries (66 in 1899, producing 146,775 gallons of pure spirit), olive-oil mills, the manufacture of casks and porcelain, iron-works and foundries are the most important of the industries. The principal ports are Brindisi, Gallipoli, Taranto, Bari, Barletta, Molfetta, Manfredonia, Trani, Bisceglie, Mola di Bari, and Monopoli. Apart from these, the more important towns are Lecce, Foggia, Bitonto, San Severo, Cerignola, Andria, and Terlizzi.

Apure. See ORINOCO.

Apurimac, an interior department of southern Peru, with an area of 8187 square miles and a population officially estimated at 177,387 in 1896. It embraces five provinces, Andahuaylas, Abancay, Cotabambas, Aymaraes, and Antabamba. The principal towns are Andahuaylas and Abancay.

Aquaria for a marine flora and fauna, which in 1875 (the date of the article on this subject in the ninth edition of this Encyclopædia) were little more than domestic toys, or show-places of a popular character, have of late years not only assumed a profound scientific importance for the convenient study of anatomical and physiological problems in marine botany and zoology, but have also attained an economic value, as offering the best opportunities for that study of the habits and environment of marketable food-fish without which no steps for the improvement of sea-fisheries can be safely taken. The numerous "zoological stations" which have sprung up, chiefly in Europe and the United States, but also in the British colonies and Japan, often endeavour to unite these two aims, and have in many cases become centres of experimental work in problems relating to fisheries, as well as in less directly practical subjects. Of these stations, the oldest and the most important is that at Naples, which, though designed for purely scientific objects, also encourages popular study by means of a public aquarium. The following account of this station from the pen of Dr Giesbrecht, a member of the staff, will serve to show the methods and aims, and the complex and expensive equipment of a modern aquarium:—

The zoological station at Naples is an institution for the advancement of biological science—that is, of comparative anatomy, zoology, botany, physiology. It serves this end by providing the biologist with the various objects of his study and the necessary appliances; it is not a teaching institution. The station was founded by Dr Anton Dohrn, and opened in the spring of 1874; it is the oldest and largest of all biological stations, of which there are now about thirty in existence. Its two buildings are situated near the seashore in the western town park (Villa Nazionale) of Naples. The older and larger one, 33 metres long, 24 m. deep, 16 m. high, contains on the ground floor the aquarium, which is open to the public. On the first floor there is, facing south, the principal library, ornamented with fresco paintings, and, facing north, a large hall containing twelve working tables, several smaller rooms, and the secretarial offices. On the second floor is the physiological laboratory, and on the third floor the small library, a hall with several working tables, and the dark rooms used in developing photographs. The ground floor of the smaller building, which was finished in 1887, contains the rooms in which the animals are delivered, sorted, and preserved, and the fishing tackle kept, together with the workshop of the engineer; on the first and second floors are work-rooms, amongst others the botanical laboratory; on the third floor are store-rooms. In the basement of both buildings, which is continued underneath the court, there are sea-water cisterns and filters, engines, and store-rooms. The materials for study which the station offers to the biologist are specimens of marine animals and plants which abound in the western part of the Mediterranean, and especially in the Gulf of Naples. To obtain these, two screw-steamers and several rowing boats are required, which are moored in the harbour of Mergellina, situated close by. The larger steamer, *Johannes Muller* (15 m. long, 2½ m. wide, 1 m. draught), which can steam eight to ten English miles per hour, is provided with a steam dredge working to a depth of eighty fathoms. From the small steamer, *Frank Balfour*, and the rowing boats, the fishing is done by means of tow-nets. Besides these there are fishermen and others who daily supply living material for study. The plankton (small floating animals) is distributed in the morning, other animals as required. The animals brought in by the fishermen are at once distributed amongst the biologists, whereas the material brought up by the dredges is placed in flat revolving wooden vessels, so as to give the smaller animals time to come out of their hiding-places. The students who work in the station have the first claim on specimens of plants and animals; but specimens are also supplied to museums, laboratories, and schools, and to individuals engaged in original research elsewhere. Up to the present time about 4000 such parcels have been despatched, and not infrequently live specimens of animals are sent to distant places. This side of the work has been of very great value to science. The principal appliances for study with which the station provides the biologist are work-rooms furnished with the apparatus and chemicals necessary for anatomical research and physiological experiments and tanks. Every student receives a tank for his own special use. The large tanks of the principal aquarium are also at his disposal for purposes of observation and experiment if necessary.

The water in the tanks is kept fresh by continual circulation, and is thus charged with the oxygen necessary to the life of the organisms. It is not pumped into the tanks directly from the sea, but from three large cisterns (containing 300 cubic metres), to which it again returns from the tanks. The water wasted or evaporated during this process is replaced by new water pumped into the cisterns directly from the sea. The water flows from the large cisterns into a smaller cistern, from which it is distributed by means of an electric pump through vulcanite or lead pipes to the various tanks. The water with which the tanks on the upper floors are filled is first pumped into large wooden tanks placed beneath the roof, thence it flows, under almost constant pressure, into the tanks. The water circulated in this manner contains by far the largest number of such animals as are capable of living in captivity in good condition. Some of them even increase at an undesirable rate, and it sometimes happens that young Mytilus or Ciona stop up the pipes; in laying these, therefore, due regard must be had to the arrangements for cleaning. For the cultivation of very delicate animals it is necessary to keep the water absolutely free from harmful bacteria; for this purpose large sand-filters have lately been placed in the system, through which the water passes after leaving the cisterns. Each of the smaller cisterns, which are fixed in the work-rooms, consists of two water-tanks, placed one above the other; their frames are of wrought iron and the walls generally of glass. Vessels containing minute animals can be placed between these two tanks, receiving their water through a siphon from the upper tank; the water afterwards flows away into the lower tank.

The twenty-six tanks of the public aquarium (the largest of which contains 112 cubic metres of water) have stone walls, the front portion alone being made of glass. As the tanks hold a very large number of animals in proportion to the quantity of water, they require to be well aerated. The pipes through which the water is conducted are therefore placed above the surface of the water, and the fresh supply is driven through them under strong pressure. A large quantity of air in the form of fine bubbles is thus taken to the bottom of the tank and distributed through the entire mass of water. Should the organisms which it is desired to keep alive be very minute, there is a danger of their being washed away by the circulating water. To obviate this, either the water which flows away is passed through a strainer, or the water is not changed at all, air being driven through it by means of an apparatus put into motion by the drinking-water supply.

The library contains about 9000 volumes, which students use with the help of a slip catalogue, arranged according to authors. The station has published at intervals since 1879 two periodicals treating of the organisms of the Mediterranean. One is *Fauna und Flora des Golfes von Neapel*, the other *Mittheilungen aus der Zoologischen Station zu Neapel*. The former consists of monographs in which special groups of animals and plants are most exhaustively treated and the Mediterranean species portrayed according to life in natural colours; up to the present time twenty-one zoological and five botanical monographs have appeared, making altogether 1200 4to sheets with about 400 plates. Of the *Mittheilungen*, which contain smaller articles on organisms of the Mediterranean, fourteen volumes in 8vo have been published. The station also publishes a *Zoologischer Jahresbericht*, which at first treated of the entire field of zoology, but since 1886 has been confined principally to Comparative Anatomy and Ontogeny; it appears eight to nine months after the end of the year reported. The *Guide to the Aquarium*, with its descriptions and numerous pictures, is meant to give the lay visitor an idea of the marine animal world.

There are about forty officials, amongst them six zoologists, one physiologist, one secretary, two draughtsmen, one engineer. The station is a private institution, open to biologists of all nations under the following conditions: there are agreements with the Governments of Austria, Baden, Bavaria, Belgium, Hamburg, Holland, Hesse, Italy, Prussia, Russia, Saxony, Switzerland, Hungary, Wurtemburg, the province of Naples, and the Universities of Cambridge, Oxford, Strassburg, Columbia College New York), and the British Association for the Advancement of Science, the Smithsonian Institute, and a society of women in the United States of North America (formerly also with Bulgaria, Rumania, Spain, the Academy of Sciences in Berlin, Williams College, University of Pennsylvania), by virtue of which the Governments and corporate bodies named have the right, on payment of £100 per annum, to send a worker to the station; this places at his disposal a "table" or workplace, furnished with all the necessary appliances and materials as set down in the agreement. At present there are agreements for thirty-three tables, and since the foundation of the station nearly 1200 biologists have worked there. The current expenses are paid out of the table-rents, the entrance fees to the public aquarium, and an annual subvention paid by the German Empire.

In England a station on similar lines, but on a smaller scale, is maintained at Plymouth by the Marine Biological Association of the United Kingdom, with the help of subsidies from the Government and the Fishmongers' Company.

Little difficulty is experienced in maintaining, breeding, and rearing fresh-water animals in captivity, but for many various reasons it is only by unremitting attention and foresight that most marine animals can be kept even alive in aquaria, and very few indeed can be maintained in a condition healthy enough to breed. Much experience, however, has been gained of late years at considerable expense, both at home and abroad. In starting a marine aquarium of whatever size, it should be obvious that the first consideration must be a supply of the purest possible water, as free as may be, not only from land-drainage and sewage, but also from such suspended matters as chalk, fine sand, or mud. This is most ideally and economically secured by placing the station a few feet above high-water mark, in as sheltered a position as possible, on a rocky coast, pumping from the sea to a large reservoir above the station, and allowing the water to circulate gently thence through the tanks by gravity (Banyuls). At an inland aquarium (Berlin, Hamburg), given pure water in the first instance, excellent if less complete results may nevertheless be obtained. The next consideration is the method by which oxygen is to be supplied to the organisms in the aquarium. Of the two methods hitherto in use, that of pumping a jet of air into tanks otherwise stagnant or nearly so (Brighton), while supplying sufficient oxygen, has so many other disadvantages, that it has not been employed regularly in any of the more modern aquaria. It is, however, still useful in aerating quite small bodies of water in which hardy and minute organisms can be isolated and kept under control. In the other method, now in general use, a fine jet of water under pressure falls on to the surface of the tank; this carries down with it a more than sufficient air-supply, analysis showing in some cases a higher percentage of oxygen in aquarium water than in the open sea.

This water supply is best effected by gravity from reservoirs placed above the tanks, but may be also achieved by direct pumping from low reservoirs or from the sea to the tanks. Provided that an unlimited supply of pure water can be obtained cheaply, the overflow from the tanks is best run to waste; but in aquaria less fortunately placed, it returns to a storage low-level reservoir, from which it is again pumped, thus circulating round and round (Naples, Plymouth). The storage reservoirs should be in all cases very large in comparison with the bulk of water in circulation; if practicable, they should be excavated in rock, and lined with the best cement. There is no reason why they should not be shallow, exposed to light and air, and cultivated as rock-pools by the introduction of seaweeds and small animals, but they must then be screened from rain, cold, and dust. The pumps used in circulation will be less likely to kill minute animals if of the plunger or ram type, rather than rotary, and should be of gun-metal or one of the new bronze-alloys which take a patina in salt water. For the circulating pipes many materials have been tried. Vulcanite is not only expensive and brittle, but has other disadvantages; common iron pipes, coated internally with cement or asphalt, or glazed internally, with all unions and joints cemented, have been used with more or less success. Probably best of all is common lead piping, the joints being served with red-lead; water should be circulated through such pipes till they become coated with insoluble carbonate, for some time before animals are put into the tanks. For small installations glass may be used, the joints being made with marine glue or other suitable cement.

In building the tanks themselves, regard must be had to their special purposes. If intended for show-tanks for popular admiration, or for the study of large animals, they must be large with a plate-glass front; for ordinary scientific work small tanks with all sides opaque are preferable from every point of view. According to their character, size, and position, fixed tanks may be of brickwork, masonry, or rock, coated in each case with cement;

asphalting the sides offers no particular advantages, and often gives rise to great trouble and expense. All materials, and especially the cements, must be of the finest quality procurable. For smaller and movable tanks, slate slabs bolted or screwed together have some disadvantages, notably those of expense, weight, and brittleness, but are often used. Better, cheaper, and lighter, if less permanent, are tanks of wood bolted together, pitched internally. Glass bell-jars, useful in particular cases, should generally have their sides darkened, except when required for observation. Provision should always be made for cleaning every part of the tanks, pipes, and reservoirs; all rock-work in tanks should therefore be removable. As regards the lighting of fixed tanks, it should always be directly from above. In all tanks with glass sides, whether large or small, as much light as possible should be kept from entering through the glass; otherwise, with a side-light, many animals become restless, and wear themselves out against the glass, affected by even so little light as comes through an opposite tank.

In cases where distance from the sea or other causes make it impracticable to allow the overflow from the tanks to run to waste, special precautions must be taken to keep the water pure. Chemically speaking, the chief character of the water in an aquarium circulation, when compared with that of the open sea, lies in the excessive quantity of nitrogen present in various forms, and the reduced alkalinity; these two being probably connected. The excess of nitrogen is referable to dead animals, to waste food, and to the excreta of the living organisms. The first two of these sources of contamination may be reduced by care and cleanliness, and by the maintenance of a flow of water sufficient to prevent the excessive accumulation of sediment in the tanks. The following experiment shows the rapid rise of nitrogen if unchecked. A tank with a considerable fauna was isolated from the general circulation and aerated by four air-jets, except during hours 124-166 of the experiment; column I. shows per 100,000 the nitrogen estimated as ammonia, column II. the total inorganic nitrogen:—

	I.	II.
Sea water at source of original supply	0·001	0·003
Aquarium water in tank at commencement of experiment .	0·012	0·400
After 22½ hours . . .	0·020	..
,, 75 ,, ...	0·025	1·200
,, 93 ,, ...	0·019	...
,, 121½ ,, ...	0·012	...
,, 141 ,, ...	0·015	2·200
,, 165 ,, ...	0·025	...
,, 169 ,, ...	0·025	...
,, 189 ,, ...	0·012	...

During this time the alkalinity was reduced to the equivalent of 30 mg. $CaCO_3$ per litre, ocean water having an alkalinity equivalent to 50-55 mg. per litre. It has been suggested that the organic nitrogen becomes oxidized into nitrous, then into nitric acid, which lowers the carbonate values. A great deal of reduction of this nitrogenous contamination can be effected by filtration, a method first introduced successfully at Hamburg, where a most thriving aquarium has been maintained by the local Zoological Society for many years on the circulation principle, new water being added only to compensate for waste and evaporation. The filters consist of open double boxes, the inner having a bottom of perforated slate on which rests rough gravel; on the latter is fine gravel, then coarse, and finally fine sand. Filtration may be either upwards or downwards through the inner box to the outer. Such filters, intercalated between tanks and reservoir, have been shown by analysis to stop a very large proportion of nitrogenous matter. It is doubtful whether aquarium water will not always show an excess of nitrogenous compounds, but they must be kept down in every way possible. In small tanks, well lighted, sea-weeds can be got to flourish in a way that has not been found practicable in large tanks with a circulation; these, with Lamellibranchs and small Crustacea as scavengers, will be found useful in this connexion. Slight or occasional circulation should be employed here also, to remove the film of dust and other matters, which otherwise covers the surface of the water and prevents due oxygenation.

In such small tanks for domestic use the fauna must be practically limited to bottom-living animals, but for purposes of research it is often desired to keep alive larval and other surface-swimming animals (plankton). In this case a further difficulty is presented, that of helping to suspend the animals in the water, and thus to avoid the exhaustion and death which soon follow their unaided efforts to keep off the bottom; this duty is effected in nature by specific gravity, tide, and surface current. In order to deal with this difficulty a simple but efficient apparatus has been devised by Mr E. T. Browne; a "plunger," generally a glass plate or filter funnel, moves slowly up and down in a bell-jar or other small tank, with a period of rest between each stroke; the motive power is obtained through a simple bucket-and-siphon arrangement worked by the overflow from other tanks. This apparatus (first used at the Plymouth Laboratory of the Marine Biological Association in 1897, and since introduced into similar institutions), by causing slight eddies in the water, keeps the floating fauna in suspension, and has proved very successful in rearing larvæ and in similar work. (G. H. Fo.)

Aqueduct.—The term aqueduct, although properly including artificial works of every kind by means of which water is conveyed from one place to another, is generally used in a more limited sense. It is, in fact, rarely employed except in cases where the work is of considerable magnitude and importance, and where the water flows naturally by gravitation.

Aqueducts and water supply.

The most important purpose for which aqueducts are constructed is that of conveying pure water, from sources more or less distant, to large masses of population. Where towns are favourably situated the aqueduct may be very short and its cost bear a relatively small proportion to the total outlay upon a scheme of water supply, but where distant sources have to be relied upon the cost of the aqueduct becomes one of the most important features in the scheme, and the quantity of water obtainable must be considerable to justify the outlay. Hence it is that only very large towns can undertake the responsibility for this expenditure, though, either voluntarily on the part of the promoters, or by the action of Parliament, smaller sanitary districts near the aqueduct are allowed to become customers for the water. In Great Britain it has, in fact, in all large schemes become a condition that, when a town is permitted to go outside its own watershed, it shall, subject to a priority of a certain number of gallons per day per head of its own inhabitants, allow local authorities, any part of whose district is within a certain number of miles of the aqueduct, to take a supply on reasonable terms. The first case in which this principle was adopted on a large scale was the Thirlmere scheme, sanctioned by Parliament in 1879, for augmenting the supply of Manchester. The previous supply was derived from a source only about 15 miles distant, and the cost of the aqueduct, chiefly cast-iron pipes, was insignificant compared with the cost of the impounding reservoirs. But Thirlmere is 96 miles distant from the service reservoir near Manchester, and the cost of the aqueduct was more than 90 per cent. of the total cost. As a supply of about 50,000,000 gallons a day is available the outlay was justifiable, and the water is in fact very cheaply obtained. Liverpool derives a supply of about 40,000,000 gallons a day from the river Vyrnwy in North Wales, 68 miles distant, and Birmingham is constructing works for impounding water in Radnorshire, and conveying it a distance of 74 miles, the supply being about 75,000,000 gallons a day. In the year 1899 an Act of Parliament was passed authorizing the towns of Derby, Leicester, Sheffield, and Nottingham, jointly to obtain a supply of water from the head waters of the river Derwent in Derbyshire. Leicester is 60 miles distant from this source, and its share of the supply is about 10,000,000 gallons a day. For more than half the distance, however, the aqueduct is common to Derby and Nottingham, which together are entitled to about 16,000,000 gallons a day, and the expense to Leicester is correspondingly reduced. These are the most important cases of long aqueducts in England, and all are subsequent to 1879. It is obvious, therefore, how greatly the design and construction of the aqueduct have grown in importance, and what care must be exercised in order that the supply upon which such large populations depend may not be interrupted, and that the country through which such large volumes of water are conveyed may not be flooded in consequence of the failure of any of the works.

Construction.

Practically only two types of aqueduct are used in England. The one is built of concrete, brickwork, &c., the other of cast-iron (or, in special circumstances, steel) pipes. In the former type the water surface coincides with the hydraulic gradient, and the conditions are those of an artificial river; the aqueduct must therefore be carefully graded throughout, so that the fall available between source and termination may be economically distributed. This condition requires that the ground in which the work is built shall be at the proper elevation; if at any point this is not the case, the aqueduct must be carried on a substructure built up to the required level. Such large structures are, however, extremely expensive, and require elaborate devices for maintaining watertightness against the expansion and contraction of the masonry due to changes of temperature. They are now only used where their length is very short, as in cases where mountain streams have to be crossed, and even these short lengths are avoided by some engineers, who arrange that the aqueduct shall pass, wherever practicable, under the streams. Where wide valleys interrupt the course of the built aqueduct, or where the absence of high ground prevents the adoption of that type at any part of the route, the cast-iron pipes hereafter referred to are used.

Masonry aqueducts.

The built aqueduct may be either in tunnel, or cut-and-cover, the latter term denoting the process of cutting the trench, building the floor, side-walls, and roof, and covering with earth, the surface of the ground being restored as before. For works conveying water for domestic supply, the aqueduct is in these days, in England, always covered. Where, as is usually the case, the water is derived from a tract of mountainous country, the tunnel work is sometimes very heavy. In the case of the Thirlmere aqueduct, out of the first 13 miles the length of the tunnelled portions is 8 miles, the longest tunnel being 3 miles in length. Conditions of time, and the character of the rock, usually require the use of machinery for driving, at any rate in the case of the longer tunnels. For the comparatively small tunnels required for aqueducts, two percussion drilling machines are usually mounted on a carriage, the motive power being derived from compressed air sent up the tunnel in pipes. The holes when driven are charged with explosives and fired. In the Thirlmere tunnels, driven through very hard Lower Silurian strata, the progress was about 13 yards a week at each face, work being carried on continuously day and night for six days a week. Where the character of the country through which the aqueduct passes is much the same as that from which the supply is derived, the tunnels need not be lined with concrete, &c., more than is absolutely necessary for retaining the water and supporting weak places in the rock; the floor, however, is nearly always so treated. The lining, whether in tunnel or cut-and-cover, may be either of concrete, or brickwork, or of concrete faced with brickwork. To ensure the impermeability of work constructed with these materials is in practice somewhat difficult, and no matter how much care is taken by those supervising the workmen, and even by the workmen themselves, it is impossible to guarantee entire freedom from trouble in this respect. With a wall only about 15 inches thick, any neglect is certain to make the work permeable; frequently the labourers do not distribute the broken stone and fine material of the concrete uniformly, and no matter how excellent the design, the quality of materials, &c., a leak is sure to occur at such places (unless, indeed, the pressure of the outside water is superior and an inflow occurs). A further cause of trouble lies in the water which flows from the strata on to the concrete, and washes away some of the cement upon which the work depends for its watertightness, before it has time to set. For this reason it is advisable to put in the floor before, and not after, the side-walls and arch have been built, otherwise the only outlet for the water in the strata is through the ground on which the floor has to be laid. Each length of about 20 feet should be completely constructed before the next is begun, the water then having an easy exit at the leading end. Manholes, by which the aqueduct can be entered, are usually placed in the roof at convenient intervals; thus, in the case of the Thirlmere aqueduct, they occur at every quarter of a mile.

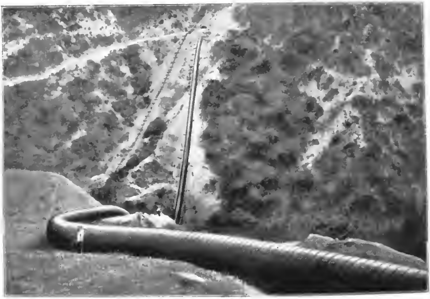
Timber aqueducts.

In some parts of America aqueducts are frequently constructed of wood, being then termed flumes. These are probably more extensively used in California than in any other part of the world, for conveying large quantities of water which is required for hydraulic mining, for irrigation, for the supply of towns, and for transporting timber. The flumes are frequently carried along precipitous mountain slopes, and across valleys, supported on trestles. In Fresno county, California, there is a flume 52 miles in length for transporting timber from the Sierra Nevada Mountains to the plain below; it has a rectangular V-shaped section, 3 feet 7 inches wide at the top, and 21 inches deep vertically. The boards which form the sides are 1¼ inches thick, and some of the trestlework is 130 feet high. The steepest grade occurs where there is a fall of 730 feet in a length of 3000 feet. About 9,000,000 feet of timber were used in the construction. At San Diego there is a flume 35 miles long for irrigation and domestic supply, the capacity being 50 feet per second; it has 315 trestle bridges (the longest of which is that across Los Coches Creek, 1794 feet in length and 65 feet in height) and 8 tunnels, and the cost was $900,000. The great bench flume of the Highline canal, Colorado, is 2640 feet in length, 28 feet wide, and 7 feet deep; the gradient is 5·28 feet per mile, and the discharge 1184 feet per second.

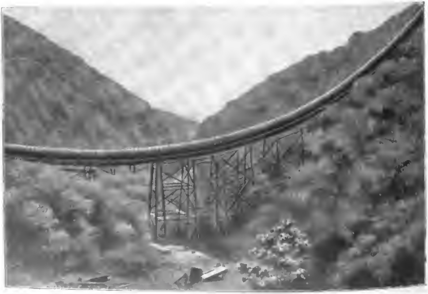
As previously stated, the type of aqueduct built of concrete, &c., can only be adopted where the ground is sufficiently elevated to carry it, and where the quantity of water to be conveyed makes it more economical than piping. Where the falling contour is interrupted by valleys too wide for a masonry structure above the surface of the

The Nadrâi Aqueduct.

Wooden Aqueduct or Flume.



Wooden Pipe Aqueduct, with Wrought-iron Rings.



Wooden Aqueduct crossing a Valley on a Trestle.

ground, the detached portions of the built aqueduct must be connected by rows of pipes laid beneath, and following the main undulations of, the surface. In such cases the built aqueduct terminates in a chamber of sufficient size to enclose the mouths of the several pipes, which, thus charged, carry the water under the valley up to a corresponding chamber on the further hillside from which the built aqueduct again carries on the supply. These connecting pipes are sometimes called siphons, although they have nothing whatever to do with the principle of a siphon, the water simply flowing into the pipe at one end and out at the other under the influence of gravity, and the pressure of the atmosphere being no element in the case. The pipes are almost always made of cast-iron, except in such cases as the lower part of some siphons, where the pressure is very great, or where they are for use abroad, when considerations of weight are of importance, and when they are made of rolled steel with riveted or welded seams. It is frequently necessary to lay them in deep cuttings, in which case cast-iron is much better adapted for sustaining a heavy weight of earth than the thinner steel, though the latter is more adapted to resist internal pressure. Mr D. Clarke in the *Trans. Am. Soc. C. E.* vol. xxxviii. p. 93, gives some particulars of a riveted steel pipe 24 miles long, 33 to 42 inches' diameter, varying in thickness from 0·22 inch to 0·375 inch. After a length of 9 miles had been laid, and the trench refilled, it was found that the crown of the pipe had been flattened by an amount varying from ½ inch to 4 inches. Steel pipes suffer more from corrosion than those made of cast-iron, and as the metal attacked is much thinner the strength is more seriously reduced. These considerations have prevented any general change from cast-iron to steel.

Aqueduct in iron piping.

Mr Clemens Herschell has made some interesting remarks (*Proc. Inst. C. E.* vol. cxv. p. 162) as to the circumstances in which steel pipes have been found preferable to cast-iron. He says that it had been demonstrated by practice that cast-iron cannot compete with wrought-iron or steel pipes in the States west of the Rocky Mountains, on the Pacific slope. This is due to the absence of coal and iron ore in these States, and to the weight of the imported cast-iron pipes compared with steel pipes of equal capacity and strength. The works of the East Jersey Water Company for the supply of Newark, N.J., include a riveted steel conduit 48 inches in diameter and 21 miles long. This conduit is designed to resist only the pressure due to the hydraulic gradient, in contradistinction to that which would be due to the hydrostatic head, this arrangement saving 40 per cent. in the weight and cost of the pipes. For the supply of Rochester, N.Y., there is a riveted steel conduit 36 inches in diameter and 20 miles long; and for Alleghany City, Pennsylvania, there is a steel conduit 5 feet in diameter and nearly 10 miles long. The works for bringing the water from La Vigne and Verneuil to Paris, include a steel main 5 feet in diameter between St Cloud and Paris.

Cast-iron pipes rarely exceed 48 inches in diameter, and even this diameter is only practicable where the pressure of the water is low. In the Thirlmere aqueduct the greatest pressure is nearly 180 lb on the square inch, the pipes where this occurs being 40 inches in diameter and 1¾ inches thick. These large pipes, which are usually made in lengths of 12 feet, are generally cast with a socket at one end for receiving the spigot end of the next pipe, the annular space being run with lead, which is prevented from flowing into the interior of the pipe by a spring ring subsequently removed; the surface of the lead is then caulked all round the outside of the pipe. A wrought-iron ring is sometimes shrunk on the outer rim of the socket, previously turned to receive it, in order to strengthen it against the wedging action of the caulking tool. Sometimes the pipes are cast as plain tubes and joined with double collars, which are run with lead as in the last case. The reason for adopting the latter type is that the stresses set up in the thicker metal of the socket by unequal cooling are thereby avoided, a very usual place for pipes to crack under pressure being at the back of the socket. The method of turning and boring a portion, slightly tapered, of spigot and socket so as to ensure a watertight junction by close annular metallic contact, is not suitable for large pipes, though very convenient for smaller diameters in even ground. Spherical joints are sometimes used where a line of main has to be laid under a large river or estuary, and where, therefore, the pipes must be jointed before being lowered into the previously dredged trench. This was the case at the Willamette river, Portland, Oregon, where a length of 2000 feet was required. The pipes are of cast iron 28 inches in diameter, 1½ inches thick, and 17 feet long. The spigots were turned to a spherical surface of 20 inches' radius outside, the inside of the sockets being of a radius ⅜ inch greater. After the insertion of the spigot into the socket, a ring, 3 inches deep, turned inside to correspond with the socket, was bolted to the latter, the annular space then being run with lead. These pipes were laid on an inclined cradle, one end of which rested on the bed of the river and the other on a barge where the jointing was done; as the pipes were jointed the barge was carefully advanced, thus trailing the pipes into the trench (*Trans. Am. Soc. C. E.* vol. xxxiii. p. 257). As may be conjectured from the pressure which they have to stand, very great care has to be taken in the manufacture and handling of cast-iron pipes of large diameter, a care which must be unfailing from the time of casting until they are jointed in their final position in the ground. They are cast vertically, socket downwards, so that the densest metal may be at the weakest part, and it is advisable to allow an extra head of metal of about 12 inches, which is subsequently cut off in a lathe. An inspector representing the purchaser watches every detail of the manufacture, and if, after being measured in every part and weighed, they are found satisfactory they are proved with internal fluid pressure, oil being preferable to water for this purpose. While under pressure, they are rapped from end to end with a hand hammer of about 5 lb in weight, in order to discover defects. The wrought-iron rings are then, if required, shrunk on to the sockets, and the pipes, after being made hot in a stove, are dipped vertically in a composition of pitch and oil, in order to preserve them from corrosion. All these operations are performed under cover. A record should be kept of the history of the pipe from the time it is cast to the time it is laid and jointed in the ground, giving the date, number, diameter, length, thickness, and proof pressure, with the name of the pipe-jointer whose work closes the record. Such a history sometimes enables the cause (which is often very obscure) of a burst in a pipe to be ascertained, the position of every pipe being recorded.

Cast-iron pipes, even when dipped in the composition referred to, suffer considerably from corrosion caused by the water, especially soft water, flowing through them. One pipe may be found in as good a condition as when made, while the next may be covered with nodules of rust. The effect of the rust is twofold; it reduces the area of the pipe, and also, in consequence of the resistance offered by the rough surface, retards the velocity of the water. These two results, especially the latter, may seriously diminish the capability of discharge, and they should always be allowed for in deciding the diameter. Automatic scrapers are sometimes used with good results, but it is better to be independent of them as long as possible. In one case the discharge of pipes, 40 inches in diameter, was found to diminish at the rate of about 1 per cent. per year; in another case, where the water was soft and where the pipes were 40 inches in diameter, the discharge was diminished by 7 per cent. in ten years. An account of the state of two cast-iron mains supplying Boston with water is given in the *Trans. Am. Soc. C. E.* vol. xxxv. p. 241. These pipes, which were laid in 1877, are 48 inches in diameter and 1800 feet long. When they were examined in 1894-95, it was estimated that the tubercles of rust covered nearly one-third of the interior surfaces, the bottom of the pipe being more incrusted than the sides and top. They had central points of attachment to the iron, at which no doubt the coating was defective, and from them the tubercles spread over the surface of the surrounding coating. In this case they were removed by hand, and the coating of the pipes was not injured in the process. Cast-iron pipes must not be laid in contact with cinders from a blast furnace with which roads are sometimes made, because these corrode the metal. Mr Russell Aitken (*Proc. Inst. C. E.* vol. cxv. p. 93) found in India that cast-iron pipes buried in the soil rapidly corroded, owing to the presence of nitric acid secreted by bacteria which attacked the iron. The large cast-iron pipes conveying the water from the Tansa reservoir to Bombay are laid above the surface of the ground. Cast-iron pipes of these large diameters have not been in existence sufficiently long to enable their life to be predicted. A main, 40 inches in diameter, conveying soft water, has been in existence fifty years at Manchester, and is apparently as good as ever. In 1867 Mr J. B. Francis found that no apparent deterioration had taken place in a cast-iron main, 8 inches' diameter, which was laid in the year 1828, a period of thirty-nine years (*Trans. Am. Soc. C. E.* vol. i. p. 26). These two instances are probably not exceptional.

Pipes in England are usually laid with not less than 2 feet 6 inches of cover, in order that the water may not be frozen in a severe winter. Where they are laid in deep cutting they should be partly surrounded with concrete, so that they may not be fractured by the weight of earth above them. Angles are turned by means of special bend pipes, the curves being made of as large a radius as convenient.

Methods of laying.

In the case of the Thirlmere aqueduct, double socketed castings about 12 inches long (exclusive of the sockets) were used, the sockets being inclined to each other at the required angle. They were made to various angles, and for any particular curve several would be used connected by straight pipes 3 feet long. As special castings are nearly double the price of the regular pipes, the cost was much diminished by making them as short as possible, while a curve, made up of the slight angles used, offered practically no more impediment to the flow of water in consequence of its polygonal form, than would be the case had special bend pipes been used. In all cases of curves on a line of pipes under internal fluid pressure, there exists a resultant force tending to displace the pipes. When the curve is in a horizontal plane and the pipes are buried in the ground, the side of the pipe trench offers sufficient resistance to this force. Where, however, the pipes are above ground, or when the curve is in a vertical plane, it is necessary to anchor them in position. In the case of the Tansa aqueduct to Bombay, there is a curve of 500 feet radius near Bassein Creek. At this point the hydrostatic head is about 250 feet, and the engineer, Mr Clerke, mentions that a tendency to an outward movement of the line of pipes was observed. At the siphon under Kurla Creek the curves on the approaches as originally laid down were sharp, the hydrostatic head being there about 210 feet; here the outward movement was so marked that it was considered advisable to realign the approaches with easier curves (*Proc. Inst. C. E.* vol. cxv. p. 34). In the case of the Thirlmere aqueduct the greatest hydrostatic pressure, 410 feet, occurs at the bridge over the river Lune, where the pipes are 40 inches in diameter, and in descending from the bridge make reverse angles of 31½°. The displacing force at each of these angles amounts to 54 tons, and as the design includes five lines of pipes, it is obvious that the anchoring arrangements must be very efficient. The steel straps used for anchoring these and all other bends were curved to fit as closely as possible the castings to be anchored. Naturally the metal was not in perfect contact, but when the pipes were charged the disappearance of all the slight inequalities showed that the straps were fulfilling their intended purpose. At every summit on a line of pipes one or more valves must be placed in order to allow the escape of air, and they must also be provided on long level stretches, and at changes of gradient where the depth of the point of change below the hydraulic gradient is less than that at both sides, causing what may be called a virtual summit. It is better to have too many than too few, as accumulations of air may cause an enormous diminution in the quantity of water delivered. In all depressions discharge valves should be placed for emptying the pipes when desired, and for letting off the sediment which accumulates at such points. Automatic valves are frequently placed at suitable distances for cutting off the supply in case of a burst. At the inlet mouth of the pipe they may depend for their action on the sudden lowering of the water (due to a burst in the pipe) in the chamber from which they draw their supply, causing a float to sink and set the closing arrangement in motion. Those on the line of main are started by the increased velocity in the water, caused by a burst on the pipe at a lower level. The water, when thus accelerated, is able to move a disc hung in the pipe at the end of a lever and weighted so as to resist the normal velocity; this lever releases a catch, and a door is then gradually revolved by weights until it entirely closes the pipe. Reflux valves on the ascending leg of a siphon prevent water from flowing back in case of a burst below them; they have doors hung on hinges, opening only in the normal direction of flow. Due allowance must be made, in the amount of head allotted to a pipe, for any head which may be absorbed by such mechanical arrangements as those described where they offer opposition to the flow of the water. These large mains require most careful and gradual filling with water, and constant attention must be given to the air-valves to see that the gutta-percha balls do not wedge themselves in the openings. A large mass of water, having a considerable velocity, may cause a great many bursts by water-ramming, due to the admission of the water at too great a speed. In places where iron is absent and timber plentiful, as in some parts of America, pipes, even of large diameter and in the most important cases, are sometimes made of wooden staves hooped with iron. A description of two of these will be found below.

Thirlmere.

The *Thirlmere Aqueduct*, to which reference has been made above, is capable of conveying 50,000,000 gallons a day from Thirlmere, in the English lake district, to Manchester. The total length of 96 miles is made up of 14 miles of tunnels, 37 miles of cut-and-cover, and 45 miles of cast-iron pipes, five rows of the latter being required. The tunnels where lined, and the cut-and-cover, are formed of concrete, and are 7 feet in height and width, the usual thickness of the concrete being 15 inches. The inclination is 20 inches per mile. The floor is flat from side to side, and the side-walls are 5 feet high to the springing of the arch, which has a rise of 2 feet. The water from the lake is received in a circular well 65 feet deep and 40 feet in diameter, at the bottom of which there is a ring of wire-gauze strainers. Wherever the concrete aqueduct is intersected by valleys, cast-iron pipes are laid; at present only one of the five rows 40 inches in diameter has been laid, as the city does not yet require its present supply to be augmented by more than 10,000,000 gallons a day. All the elaborate arrangements described above for stopping the water in case of a burst have been employed, and have perfectly fulfilled their duties in the few cases in which they have been called into action. The water is received in a service reservoir at Prestwich, near Manchester, from which it is supplied to the city. The supply from this source was begun in 1894. The total cost of the complete scheme will not be far short of £5,000,000, of which rather under £3,000,000 had been spent up to the date of the opening.

Vyrnwy.

The *Vyrnwy Aqueduct* was sanctioned by parliament in 1880 for the supply of Liverpool from North Wales, the quantity of water obtainable being at least 40,000,000 gallons a day. A tower built in the artificial lake from which the supply is derived, contains the inlet and arrangements for straining the water. The aqueduct is 68 miles in length, and for nearly the whole distance will consist of three lines of cast-iron pipes, one of which, varying in diameter from 42 inches to 39 inches, is now in use. As the total fall between Vyrnwy and the termination at Prescot reservoirs is about 550 feet, arrangements had to be made to ensure that no part of the aqueduct be subjected to a greater pressure than is required for the actual discharge. Balancing reservoirs have therefore been constructed at five points on the line, advantage being taken of high ground where available, so that the total pressure is broken up into sections. At one of these points, where the ground level is 110 feet below the hydraulic gradient, a circular tower is built, making a most imposing architectural feature in the landscape. At the crossing of the river Weaver, 100 feet wide and 15 feet deep, the three pipes, here made of steel, were connected together laterally, floated into position, and sunk into a dredged trench prepared to receive them. Under the river Mersey the pipes are carried in a tunnel, from which, during construction, the water was excluded by compressed air.

Denver.

Denver Aqueduct.—The new supply to Denver City, initiated by the Citizens Water Company in 1889, is derived from the Platte river, rising in the Rocky Mountains. The first aqueduct constructed is rather over 20 miles in length, of which a length of 16½ miles is made of wooden stave pipe, 30 inches in diameter. The maximum pressure is that due to 185 feet of water; the average cost of the wooden pipe was $1.36½ per foot, and the capability of discharge 8,400,000 gallons a day. Within a year of the completion of the first conduit, it became evident that another of still greater capacity was required. This was completed in April 1893; it is 34 inches in diameter and will deliver 16,000,000 gallons a day. By increasing the head upon the first pipe, the combined discharge is 30,000,000 gallons a day. An incident in obtaining a temporary supply, without waiting for the completion of the second pipe, was the construction of two wooden pipes, 13 inches in diameter, crossing a stream with a span of 104 feet, and having no support other than that derived from their arched form. One end of the arch is 24½ feet above the other end, and, when filled with water, the deflection with eight men on it was only ⅜ of an inch. A somewhat similar arch, 60 feet span, occurs on the 34-inch pipe where it crosses a canal. Mr Schuyler points out (*Trans. Am. Soc. C. E.* vol. xxxi. p. 148) that the fact that the entire water supply of a city of 150,000 inhabitants is conveyed in wooden mains, is so radical a departure from all precedents, that it is deserving of more than a passing notice. He says that it is manifestly and unreservedly successful, and has achieved an enormous saving in cost. The sum saved by the use of wooden, in preference to cast-iron pipes, is estimated at $1,100,000 dollars. It is perhaps necessary to state that the pipe is buried in the ground in the same way as metal pipes. The edges of the staves are dressed to the radius with a minute tongue 1/16 inch high on one edge of each stave, but with no corresponding groove in the next stave; its object is to ensure a close joint when the bands are tightened up. Leaks seldom or never occur along the longitudinal seams, but the end shrinkage caused troublesome joint leaks. The shrinkage in California redwood, which had seasoned 60 to 90 days before milling, was frequently as much as 3 inches in the 20 staves that formed the 34-inch pipe, and the space so formed had to be filled by a special closing stave. Metallic tongues, ⅜ inch deep, are inserted at the ends of abutting staves, in a straight saw cut. The bands, which are of mild steel, have a head at one end and a nut and washer at the other; the ends are brought together on a wrought-iron shoe, against which the nut and washer set. The staves forming the lower half of the pipe are placed on an outside, and the top staves on an inside, mould. While the bands are being adjusted the pipe is rounded out to bring the staves out full, and the staves are carefully driven home on to the abutting staves. The spacing of the bands depends on circumstances, but is about 150 bands per 100 feet. With low heads the limit of spacing was fixed at 17 inches. The outer surface of the pipe, when charged, shows moisture oozing slightly over the entire surface. This condition Mr. Schuyler considers an ideal one for perfect preservation, and the staves were kept as thin as possible to ensure its occurrence. Samples taken from pipes in use from three to nine years are quite sound, and it is concluded that the wood will last as long as cast iron if the pipe is kept constantly charged. The bands are the only perishable portion, and their life is taken at from fifteen to twenty years. Other portions of the second conduit for a length of nearly 3 miles were formed of concrete piping, 38 inches' diameter, formed on a mould in the trench, the thickness being 2½ to 3 inches. So successful an instance of the use of wooden piping on a large scale, is sure to lead to a large development of this type of aqueduct in districts where timber is plentiful and iron absent.

Pioneer, Utah.

Pioneer Aqueduct, Utah.—The construction of the Pioneer Aqueduct, Utah, was begun in 1896 by the Pioneer Electric Power Company, near the city of Ogden, 35 miles north of Salt Lake City. The storage reservoir, from which it draws its water, will cover an area of 2000 acres, and contain about 15,000 million gallons of water. The aqueduct is a pipe 6 feet in diameter, and of a total length of 6 miles; for a distance of rather more than 5 miles it is formed of wooden staves, the remainder, where the head exceeds 117 feet, being of steel. It is laid in a trench and covered to a depth of 3 feet. The greatest pressure on the steel pipe is 200 lb per square inch, and the thickness varies from ⅜ to 1¼ inch. The pipe was constructed according to the usual practice of marine boiler-work for high pressures, and each section, about 9 feet long, was dipped in asphalt for an hour. These sections were supported on timber blocking, placed from 5 to 9 feet apart, and consisting of three to six pieces of 6 × 6 inch timbers laid one on the top of the other; they were then riveted together in the ordinary way. The wooden stave-pipe is of the type successfully used in the Western States for many years, but its diameter is believed to be unequalled for any but short lengths. There were thirty-two staves in the circle, 2 inches in thickness, and about 20 feet long, hooped with round steel rods ⅝ inch in diameter, each hoop being in two pieces. The pipe is supported at intervals of 8 feet by sills 6 × 8 inches and 8 feet long. The flow through it is 250 cubic feet per second.

Santa Ana.

The *Santa Ana Canal* was constructed for irrigation purposes in California, and is designed to carry 240 cubic feet of water per second (*Trans. Am. Soc. C. E.* vol. xxxiii. p. 99). The cross section of the flumes shows an elliptical bottom and straight sides consisting of wooden staves held together by iron and steel ribs. The width and depth are each 5 feet 6 inches, the intended depth of water being 5 feet. The staves are held by T-iron supports resting on wooden sills spaced 8 feet apart, and are compressed together by a framework. They were caulked with oakum, on the top of which, to a third of the total depth, hot asphalt was run. The use of nails was altogether avoided except in parts of the framework, it being noticed that decay usually starts at nail holes. It was found possible to make the flume absolutely watertight, and in case of repair being necessary at any part the framework is easily taken to pieces so that new staves can be inserted. The water in the flume has a velocity of 9·6 feet per second. The Warm Springs, Deep, and Morton, cañons on the line are crossed by wooden stave pipes 52 inches in diameter, bound with round steel rods, and laid above the surface of the ground. The work is planned for two rows of pipes, each capable of carrying 123 cubic feet per second; of these one so far has been laid. The lengths of the pipes at each of the three cañons are 551, 964, and 756 feet respectively, and the maximum head at any place is 160 feet. The pipes are not painted, and it has been suggested that they would suffer in their exposed position in case of a bush fire, a contingency to which, of course, flumes are also liable.

New York.

Aqueducts of New York.—There are three aqueducts in New York—the Old Croton Aqueduct (1837-43), the Bronx River Conduit (1880-85), and the New Croton Aqueduct (1884-93), discharging respectively 95, 28, and 302 million U.S. gallons a day; their combined delivery is therefore 425 million gallons a day. The Old Croton Aqueduct is about 41 miles in length, and was constructed as a masonry conduit, except at the Harlem and Manhattan valleys, where two lines of 36-inch pipe were used. The inclination of the former is at the rate of about 13 inches per mile. The area of the cross-section is 53·34 square feet, the height is 8½ feet, and the greatest width 7 feet 5 inches; the roof is semicircular, the floor segmental, and the sides have a batter on the face of ½ inch per foot. The sides and invert are of concrete, faced with 4 inches of brickwork, the roof being entirely of brickwork. There is a bridge over the Harlem river 1450 feet in length, consisting of fifteen semicircular arches; its soffit is 100 feet above high water, and its cost was $963,427. The construction of the New Croton Aqueduct was begun in 1885, and the works were sufficiently advanced by 15th July 1890 to allow the supply to be begun. The lengths of the various parts of the aqueduct are as follows:—

	Miles.
Tunnel	29·75
Cut-and-cover	1·12
Cast-iron pipes, 48 inches diameter, 3 rows	2·38
Croton Inlet to Central Park	33·25

The length of tunnel under pressure (circular form) is 7·17 miles, and that not under pressure (horse-shoe form) 23·70 miles. The maximum pressure in the former is 55 lb per square inch. The width and height of the horse-shoe form are each 13 feet 7 inches, and the diameter of the circular form (with the exception of two short lengths) is 12 feet 3 inches. The reason for constructing the aqueduct in tunnel for so long a distance was the enhanced value of the low-lying ground near the old aqueduct. The tunnel deviates from a straight line only for the purpose of intersecting a few transverse valleys at which it could be emptied. For 25 miles the gradient is 0·7 foot per mile; the tunnel is then depressed below the hydraulic gradient, the maximum depth being at the Harlem river, where it is 300 feet below high water. The depth of the tunnel varies from 50 to 500 feet from the surface of the ground. Forty-two shafts were sunk to facilitate driving, and in four cases where the surface of the ground is below the hydraulic gradient these are closed by watertight covers. The whole of the tunnel is lined with brickwork from 1 to 2 feet in thickness, the voids behind the lining being filled with rubble-in-mortar. The entry to the old and new aqueducts is controlled by a gate-house of elaborate and massive design, and the pipes which take up the supply at the end of the tunnel are also commanded by a gate-house. The aqueduct, where it passes under the Harlem river, is worthy of special notice. As it approaches the river it has a considerable fall, and eventually ends in a vertical shaft 12 feet 3 inches in diameter (where the water has a fall of 174 feet), from the bottom of which, at a depth of 300 feet below high-water level, the tunnel under the river starts. The latter is circular in form, the diameter being 10 feet 6 inches, and the length is 1300 feet; it terminates at the bottom of another vertical shaft also 12 feet 3 inches in diameter. The depth of this shaft, measured from the floor of the lower tunnel to that of the upper tunnel leading away from it, is 321 feet; it is continued up to the surface of the ground, though closed by double watertight covers a little above the level of the upper tunnel. Adjoining this shaft is another shaft of equal diameter, by means of which the water can be pumped out, and there is also a communication with the river above high-water level, so that the higher parts can be emptied by gravitation. The cost of the Old Croton Aqueduct was $11,500,000; that of the new aqueduct is not far short of $20,000,000.

Nadrai.

The *Nadrai Aqueduct Bridge*, opened at the end of 1889, is the largest structure of its kind in existence. It was built to carry the water of the Lower Ganges canal over the Kali Nadi, in connexion with the irrigation canals of the north-west provinces of India. In the year 1888-89 this canal had 564 miles of main line, with 2050 miles of minor distributaries, and irrigated 519,022 acres of crops. The new bridge replaces one of much smaller size (five spans of 35 feet), which was completely destroyed by a high flood in July 1885. It gives the river a waterway of 21,000 square feet, and the canal a waterway of 1040 square feet, the latter representing a discharge of 4100 cubic feet per second. Its length is 1310 feet, and it is carried on fifteen arches having a span of 60 feet. The width between the faces of the arches is 149 feet. The foundations below the river-bed have a depth of 52 feet, and the total height of the structure is 88 feet. It cost 44½ lakhs of rupees, and occupied four years in building. The foundations consist of 268 circular brick cylinders, and the fifteen spans are arranged in three groups, divided by abutment piers; the latter are founded on a double row of 12-feet cylinders, and the intermediate piers on a single row of 20-feet cylinders, all the cylinders being hearted with hydraulic lime concrete filled in with skips. This aqueduct-bridge has a very fine appearance, owing to its massive proportions and design.

For an account of the New York aqueducts see the *Report of the Aqueduct Commissioners*, 1887-95, and *The Water Supply of the City of New York*, 1896, by WEGMANN. For accounts of other aqueducts, see the Transactions of the Societies of Engineers in the different countries, and the Engineering Journals. (E. P. H.*)

Aquila, a town and bishop's see of Italy (Abruzzi and Molise), capital of the province of Aquila, situated in the Central Apennines, at the S.W. foot of the knot of Gran Sasso d'Italia, 145 miles N.E. from Rome by rail. There are two picture galleries, one in the town hall, the other in the Dragonetti (formerly De Torres) Palace, and an industrial arts and sciences school. University classes are held here. Owing to its altitude (2366 ft.), it is a favourite summer resort of the Italians. Population of commune (1881), 18,426; (1901), 21,215; of province (1881), 353,027; (1901), 397,645.

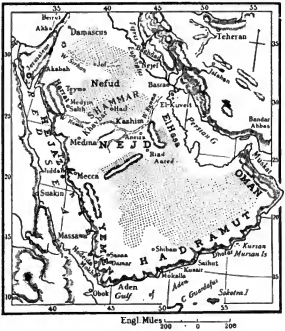
Arabi Pasha (more correctly AḤMAD ʽARĀBĪ, to which in later years he added the epithet *al-Miṣrī*, "the Egyptian"), Egyptian soldier and revolutionary leader, was born in Lower Egypt in 1839, of a fellah family. Having entered the army as a conscript he was made an officer by Said Pasha in 1862, and was employed in the transport department in the Abyssinian campaign under Ismail Pasha. A charge of peculation was made against him in connexion with this expedition and he was placed on half-pay. During this time he joined a secret society formed by Ali Roubi with the object of getting rid of Turkish officers from the Egyptian army. In 1878 he was employed by Ismail in fomenting a disturbance against the ministry of Nubar, Wilson, and De Blignières, and received in payment a wife from Ismail's harem and the command of a regiment. This increased his influence with the secret society, which, under the feeble government of Tewfik Pasha and the Dual Control, began to agitate against Europeans. A military demonstration on 8th September 1881, led by Arabi, forced the Khedive to increase the numbers and pay of the army, to substitute Cherif Pasha for Riaz Pasha as prime minister, and to convene an assembly of notables. Arabi became under-secretary for war at the beginning of 1882, but continued his intrigues. The Assembly of Notables claimed the right of voting the budget, and thus came into conflict with the foreign controllers who had been appointed to guard the interests of the bondholders in the management of the Egyptian finances. Cherif fell in February, and Arabi (created a pasha) became minister of war. Fortified by the honours bestowed on him by the sultan, Arabi, after a brief fall from office, acquired a dictatorial power that alarmed the British Government. His arming of the forts at Alexandria was held to constitute a menace to the fleet. On the refusal of France to co-operate, the British fleet bombarded the forts (11th July), and a British force, under Sir Garnet Wolseley, defeated Arabi on 13th September at Tel-el-Kebir. Arabi surrendered, and was tried (3rd December) for the crime of rebellion. In accordance with an understanding made with the British representative, Lord Dufferin, Arabi pleaded guilty, and the formal sentence of death was immediately commuted to one of banishment for life to Ceylon. After his exile had lasted for nearly twenty years, however, the Khedive, Abbas II., exercised his prerogative of mercy, and in May 1901 Arabi was permitted to return to Egypt.

ARABIA.

DURING the last quarter of the 19th century several notable journeys were made through Northern, Central, and Southern Arabia which, although they have led to no essential modification of previous views regarding the general physiography of that country, have added considerably to our knowledge of its topographical detail. Very little systematic survey has been possible in a country so remote from the centres of scientific movement, and so hostile to foreign interference. The eastern coast has been connected with the Indian system of triangulation across the Strait of Hormuz; and from Aden a local topographical survey has been carried into the southern offshoots of the Yemen Mountains by officers of the Indian Survey, based on a triangulation which is independent of India. Amongst recent investigations the researches of Dr Walker in the Sinai Peninsula have thrown new light on the coral formations of the western coast, and have elucidated some interesting problems in connexion with Arabian desert formations. According to this authority, the change in surface configuration of the desert sands of Northern Arabia is due to no change in climatic factors. It is governed by the same laws to-day as it was thousands of years ago. Sand formations are produced by the differences of temperature (50° to 80° F.), to which the surface rock is daily exposed. The rock is first broken up by these differences into small fragments, which are polished and rounded by the action of wind-blown sand. Granite, especially, disintegrates rapidly on account of the difference in the specific heat of its constituent parts. Then the wind action again separates the component parts and forms broad spaces in the desert, of which the sand particles may consist uniformly either of mica or of quartz. But as regards recent illustration of the conformation and geology of the Arabian continent generally, it is to the researches of Doughty and Blunt, between the years 1876 and 1878, and to those of Theodore Bent subsequently, that we are most indebted for fresh material from English sources.

Doughty accompanied the annual pilgrimage, or "haj," from Damascus to Mecca, stopping at Medyin Salih (some 150 miles north-west of Medina) to copy Nabathæan inscriptions and explore the monuments of El Hajr. During the spring of 1877 he visited Nejd, returning again to El Hajr and exploring the cool and lofty Harrat during the summer. He afterwards journeyed northwards to Teyma, in the Nefud, and eastwards to Hail, the residence and capital of the Emir Ibn Rashid. From Hail he returned south-west to Khaybar, crossing an upland region of lava-fields and extinct volcanoes, which he believes to be the true water-parting between east and west in Northern Arabia. In the spring of 1878 he again returned to Nejd, visiting Aneyza and Boreyda, which he describes as its two most important towns. Then recrossing the continent and traversing the elevated steppe which is the wandering ground of the great Beduin tribe, Ateyba, he finally reached Jidda, exhausted by the hardships and vicissitudes of his journey. It is worthy of note that he travelled openly as a Christian and an Englishman, and that he survived to write a standard work on Arabia; whilst Huber, who traversed much the same country in 1883-84, paid the penalty of the venture with his life. In 1878-79 Mr Wilfrid Blunt, accompanied by his intrepid wife, Lady Anne Blunt, travelled from Syria south-east to Jebel Shammar, skirting the great Wadi Sirhan depression to Jof, and thence crossing the Nefud. He thus followed a route approximately parallel to that of Doughty, at a distance of about 80 miles from it. On his return journey from Nejd he joined the bands of Persian pilgrims returning from Mecca, travelling nearly due north to Kerbela and Baghdad, passing through the country of the Daffir Beduins, so that between these two travellers we have a fairly connected account of the physiography of all Northern Arabia, differing in some important details from the earlier descriptions of Palgrave (ARABIA, *Ency. Brit.* ii. 235-265). Mr Bent, who was also accompanied by his wife, visited the Bahrein islands, on the east coast of Arabia, in 1888, and added much to our knowledge of this cradle of the Phœnician race. In 1893-94 he made an adventurous journey into the main valley of Hadramut, and later again visited the Southern Arabian coast, starting from Muskat, but was not successful in penetrating into the interior of the continent. Colonel S. B. Miles explored Oman and visited Dhofar, on the southern coasts of Arabia, in 1884. Yemen was traversed as late as 1892 by W. B. Harris, who travelled in disguise from Aden to Sanaa, the capital, where he was imprisoned by the Turkish authorities, and whence he was deported under an escort to Hodeida. In such circumstances he was not able to add much to the scientific information gained by previous travellers; but he gave an excellent descriptive account of the wonderful fertility and beauty of Arabia Felix. Stimulated by a journey of the French botanist Deflers in 1888, Dr Schweinfurth made a botanical exploration of Yemen in the winter of 1888-89, and Herr Eduard Glaser, about the same time, visited Mareb, the capital of the old Sabæan empire, and brought home with him numerous manuscripts. To the researches of these travellers in Northern, Central, Southern, and Western Arabia, we may add such matters of historical interest affecting Arabia as have been brought to light by the labours of the officers of the Indian Survey working in Baluchistan and Makrán. They undoubtedly open up a new chapter in Arabian commercial (if not military) history.

Physiography. From Doughty we learn that the geology of Arabia is of truly Arabian simplicity. A central core of Plutonic rocks is overlaid by sandstones, and these again by limestones, sometimes accompanied with flints. This is a similar formation to that which appears again between the Dead Sea and Jerusalem, and probably underlies all Palestine. The "nefuds," or deep sandy deserts, are composed of material derived from the sandstones. The occurrence of volcanic rocks upon plateaux throughout Central Arabia was previously unrecorded, but there appears to be a doubt whether the volcanic cones on the surface of the lava-flows of the "harrats" can geologically be connected with these flows. In the north-west the platform of sandstone which flanks the pilgrim route to Mecca from Damascus for about 150 miles, with its western edge approximately parallel to the Red Sea coast at a distance of about 100 miles, and which terminates southwards near El Hajr, is not the true watershed between the sand-plains of Teyma and the sea; for the drainage strikes across it from eastwards, and is possibly antecedent to the formation of the plateau. The surface of this great "harrat," or upland, which crowns the mountainous highlands of the coast, and is flanked on the east by a long extended depression, has been embedded by stream after stream of basaltic lava, and is studded with numerous extinct volcanoes. The highest of these volcanoes is estimated to be as much as 1000 feet above the plateau level. Between Shammar and Khaybar, striking south-west across the continent, the central districts consist of an upland space of lava-fields and extinct volcanoes (called "hilli-hillian" by the Arabs) rising to about 6000 feet above sea-level, forming another "harrat" known as the Harrat Khaybar. This was ascertained to be the true water-parting of this part of the country; the waters flowing eastwards to the Wadi e' Rumme (which would be an effluent of the Euphrates if it were a perennial stream instead of a dry trough flushed once in a generation) and westwards to the Wadi el Humth (previously unknown) which has its mouth on the Red Sea coast.



MAP OF ARABIA.

Blunt describes the harrats or upland plains, closely adjoining the frontiers of Syria and Arabia to the south of Damascus, as a vast expanse of boulder-strewn desert, "a bleak and gloomy region across which it is difficult to travel with camels on account of the narrowness and intricacy of the paths which wind in and out amongst the boulders." From this region of black stones, extending south-eastwards for upwards of 300 miles to Jof, is the great depression of the Wadi Sirhan (probably an ancient arm of the sea) which is estimated to be less than 2000 feet above sea-level, and is flanked to the eastward by the vast gravelly plain of El Hamad on a higher level of 500 feet. Jof is a walled town of about 500 houses, which stands on the northern edge of the Nefud or red sand-plain of the interior. This plain extends for 200 miles to the foot of the Jebel Shammar, beneath which lies Hail, which Blunt places at the foot of the northern slopes to the east of Jebel Aja, and Doughty shows to the south of that range. The rocky hills of the Nefud, like those of Jof, are of sandstone, varying in colour from yellow to red and purple, but weathered black on the upper surface. Jebel Shammar itself is composed of red granite. The general characteristics of these mountains and of their vegetation seem to be similar to those of Mount Sinai. The plain level at Hail is estimated by Blunt to be 4000 feet above sea-level, and the summits of the Shammar Mountains to be 2000 feet higher. The character of the Nefud plains apparently differs essentially from that described by Palgrave. The Nefud is now said to consist of a wide spread of coarse red sand, well clothed with shrubs, and after a rainy winter covered with grass and flowers. A few irregular low ridges exist in the Nefud, but they are not a prominent feature. On the other hand, the whole plain is pitted with deep hollows, shaped like a horse-shoe, with their points all set with great regularity towards the same point of the compass. These depressions are called by the Arabs "fulj," and vary in depth from 20 to 200 feet, and proportionately in width; the widest being about a quarter of a mile across. Another natural phenomenon which was previously described in considerable detail, but which Blunt found to be unsupported by local evidence, is the occurrence of the simoom, or poisonous wind, in these plains. Sandstorms are of frequent occurrence; but they are not poisonous. The deadly poison blast, which not merely suffocates by mechanical means, but which absolutely disseminates a poisonous vapour or gas, must be dissociated from the plains of the Nefud. The expression "nejd" is ascertained to be purely geographical, and in no sense political. In Arabia it is applied to all the high-level districts lying within the Nefuds. It includes the three provinces of Jebel Shammar, Kasim, and Aared. As employed by the Turks, the name is applied to their latest conquests on the seaboard of El Hasa, and so has led to a misapprehension as to the extent of Turkish sovereignty in Arabia. The plain of the Hamad, which Blunt crossed from Jebel Shammar to the borders of Arabia at Nejef, south of Babylon, has a uniform upward grade from the Sea of Nejef to Shammar. This slope is estimated to be about 10 feet per mile, and is not unbroken. It is due to "a series of shelves terminating in abrupt edges one above the other, the edges facing the line of descent." The Nefud of Eastern Arabia, as described by Sir Lewis Pelly, differs from the Nefud north of Shammar in some essential particulars. It consists of a series of huge sand ranges trending curvilinearly in a north-west and south-east direction, stretching roughly parallel to the Arab littoral of the Persian Gulf southwards from Jebel Shammar. Between the ridges are wide spaces of hard level plain, as much as from 7 to 8 miles in width. The central plateau commences to rise into Nejd proper from the district of Sedair. The route from the Persian Gulf westward, crossing this eastern Nefud, terminates at Riad (the Wahabi capital), 250 miles to the south-east of Hail.

Hadramut and Southern Arabia.

Bent's expeditions to the south coast of Arabia and Hadramut geographically place these regions in an entirely new light. Hadramut is no longer to be regarded simply as a southern district of Arabia intervening between the sea coast and the central desert, but as a broad central artery running for a hundred miles or more parallel to the coast, through which the valleys of the high Arabian plateau discharge their scanty supplies of water to the sea near Saihut, towards which point the whole system gradually slopes. Into this hotbed of fanaticism but one European (Herr Leo Hirsch) had succeeded in penetrating before Bent, and he travelled in disguise. Theodore Bent and his wife travelled without disguise, and with a considerable train of followers. It seems to be clearly proved by the Himyaritic inscriptions found in the valley, that for five centuries B.C. the term Hadramut applied to this valley only, the meaning of it being the "Valley of Death." Here from time immemorial existed the historic trade in frankincense and myrrh, which centred in Shibam (a place of some importance even now), from whence the produce of the valley was conveyed westwards by the great frankincense road across Arabia of which an account is given to us by Claudius Ptolemæus.

The narrow coast-line of this part of Arabia is termed Sahil, and between Mokalla and Saihut it is described as a "most uncompromisingly arid country." Hot springs exist at intervals, pointing to the volcanic origin of the region, and where they are found they are utilized for the purposes of cultivation; but their occurrence is rare, and the coast generally is marked by an extended waste of barren sterility. Mokalla, Shehr, and Kosair are the chief coast towns. They carry on an active trade by means of their dhows and buggalows with Aden, Muskat, Bombay, and the Somali coast. A curious geological feature of the coast are the basalt fields near Kosair, which spread across the flat country in a stratum of black rock-like lava. The Arabs attribute this basaltic effusion to the destruction of pagan cities. Probably it is the source from whence Egypt and Assyria derived material for statuary art. The highlands beyond the strip of low coast are called Akaba. The approaches to them are formed by a series of short water-course valleys, which contain the first stages of the caravan routes into the interior. The Akaba consists of a wide expanse of flat, featureless plateau, without a habitation or even sign of life—waterless and waste—but broken by occasional masses of flat tableland formation, which lie superincumbent on the lower plain about 80 feet high. On the top level of the Akaba (a little over 4000 feet above sea), is a wide scattering of small black basaltic stones, which rest on the sandstones and limestones of which the range is formed. In the gullies cut out of these tableland formations (which are the higher level or upper flats of the Akaba), as also in the valleys approaching the plateau, the myrrh and frankincense trees, with various forms of mimosa, are to be found. It is curious that the Beduins, who own the plateau, do not themselves gather the produce of the trees, but let districts out to the Somalis, who come in due season to collect the frankincense. The air of the plateau is fresh, keen, and invigorating. The similarity of its conformation to some parts of Abyssinia is striking; and it appears that many points of similarity are also to be noted between the coasts of Southern Arabia and those of Southern Baluchistan. From the Akaba many valleys dip with rapid and sudden descent, flanked by steep red sandstone cliffs, into the main central depression of Hadramut. So steep, and so different from valleys whose formation is due to erosion, are these gates of Hadramut, that it seems possible that they are but branches of a fiord, or arm of the sea, which once filled in the whole Hadramut depression. The upper valley of the Hadramut, round about its capital of Shibam and the courtly residence of its chief at Al Katan, is a land of cultivation and prosperity, of palm groves and towns and palaces, flourishing chiefly on the basis of wealth acquired in India. The sultan, who is the head of the Al Kaiti family of the Tafi tribe, is jemadar or general of the Arab regiments in the service of the Nawab of Haidarabad. This connexion with India is the secret of the wealth of the Al Kaiti family. The dwellers in the towns, and the cultivators of Hadramut belong to races of Arabs who are of later importation into the country than the Beduin. The chief tribes are the Tafi, Ketiri, Minhali, Amri, and Tamini, who are constantly at war with the Beduin. The Beduin, who are scattered in wild tribes all over the country, are the caravan leaders and the carriers, rearing their own camels, and owning large territories in the highlands. They are numerous and powerful, never living in tents like the northern Beduin. The richer amongst them occupy houses, and the poorer, caves. The Sharifs and Saiads are an important hierarchy, tracing their descent from the prophet, and exacting the homage of all who are under their widespread influence. They boast a pedigree purer than that of any other Saiad family in Arabia. They are dwellers in towns and cities. The half-bred and imported African slaves form the fourth class of this mixed community. They are all of them Mahommedans, many of them wealthy, and some superior in education to their masters. The tillers of the soil, personal servants, and soldiers of the chiefs mostly belong to this class.

Antiquities.

The name Ad is given in the Koran to the Sabæan inhabitants of Southern Arabia, and is still recognized by the modern inhabitants. Within the limits of the coast district there is no evidence of Addite ruins, a circumstance which confirms the opinion that the ancient trade in frankincense was carried on chiefly by the caravan road passing eastwards from Aden to Hadramut and Oman, very little use being made of the harbours and ports of the sterile coast. The movable, wind-blown sand which collects in masses in the centre of the valleys, has probably long ago buried such ancient ruins as date from Himyaritic times, and all that is now observable is to be found on more elevated sites above the plain. A distinct connexion is to be traced between some of the rude stone relics of the past on which inscriptions exist, and those evidences of sun-worship which were found by Bent at Zimbabwe in Mashonaland, where the arrangement of rocks and stones possesses a similar system of orientation. Of the intimate connexion, if not actual relationship, which existed many centuries before our era between the Sabæans of Southern Arabia and those Arab people who worked the gold-mines of Mashona, and built forts to protect them, there can be little doubt. In the Wadi Sher, which leads northwards from the head of the Hadramut into the central districts, there exist the remains of at least one great Himyaritic town, with traces of megalithic buildings and a rock exhibiting Himyaritic inscriptions. This appears to have been an important position on the great caravan route between east and west. Large unhewn stones of the dolmen type, decorated on the inside with geometric patterns similar to those found in Mashonaland, together with buildings of extreme antiquity far anterior to those of other Himyaritic remains around them, also exist in the Wadi Sher. The general result of these discoveries is greatly to enlarge our views of the extent of ancient Sabæan colonization in the Eastern world, a result which is still further supported by the remarkable similarity which exists between the great irrigation works to be found in Yemen and those which yet require further investigation in Southern Baluchistan.

The remarkable connexion between the fauna and the flora of Arabia and those of the Somali country and Abyssinia, no less than the curious analogies between geological and topographical construction in the physiology of the two countries, points to a prehistoric land connexion between them on the south, as well as the north, of the Red Sea, which may possibly have been coeval with the land connexion between India and Southern Africa. The link forged in geologic ages never seems to have been entirely broken, and nothing has served to give emphasis to previous evidence on this subject more than the Zimbabwe discoveries of Theodore Bent. It is certain that the ruins and the relics in them (amongst which were found fragments of Persian and Celadon china, such as may still be found in quantities on the coast of Makrán and of the Persian Gulf) are not in any way connected with any African race. We also know that for many centuries before our era the Red Sea was alive with the ships and commerce of Arabia. Arab ships brought spices from India and the "Cania" tree from China; and "Arabian" gold is celebrated in the writings of the very earliest historians. Very little gold ever came from Arabia, but in Africa it was produced in large quantities (both from alluvial and quartz sources) from the earliest ages. There can be little doubt that the builders of Zimbabwe came from the Arabian Peninsula.

Yemen.

Although no recent travels or explorations in Yemen have added greatly to the mass of scientific information collected by Glaser, Schweinfurth, and Playfair, we have acquired a better knowledge of the chief geographical features of that country from the adventurous journey of W. B. Harris in 1892, supplemented by the researches of the Indian surveyors in the Aden district about the same period, and the earlier travels of General F. T. Haig in 1887, than we formerly possessed.

The country is split up into the two great natural divisions of the interior highlands or Jebel, and low-lying sandy deserts and plains of the seaboard. The latter are from 30 to 100 miles in breadth, skirting the highlands on the west and south, and are only broken where a spur from the mountains approaches the southern outlet of the Red Sea, forming the headland of Sidi Sheikh, exactly opposite to the island of Perim. There are many indications that this seaboard strip of desert was, until a geologically recent period, below sea-level. These plains of Yemen are called Teháma. They are subject to drought, the rainfall being extremely small, but there are, nevertheless, scattered about them, oases where cereals can be reared with success, and water may be obtained in the nullah beds by sinking wells sufficient to supply the flocks and herds of the Beduin. It is in these arid plains that some of the best of Arabian camels are bred. The chief towns of the Teháma are Hodeida and Mokha on the western coast, and Aden (*q.v.*) on the south. *Hodeida* lies on the north-east side of a large bay, sheltered by a promontory to the north-west. It is a large and flourishing town containing about 30,000 inhabitants, with a Turkish garrison. It possesses a climate which is inimical to European existence. At certain seasons of the year it is subject to frightful epidemics of fever. *Mokha* has lost its importance as a trade port since Aden has been occupied by the British. It owes its existence to the trade in coffee. Early in the 17th century English and Dutch established factories at Mokha, and a century later the French followed their example, so that for some two centuries Mokha became renowned for its wealth. On the British occupation of Aden in 1839 trade left Mokha, and since then the town has fallen into decay.

From Aden, northwards, a stretch of some 30 miles of desert separates the volcanic rocks and ridges of the coast from the green and fertile highlands of Yemen. These highlands present a most curious contrast to the arid sterility of the Teháma. Ranges of mountains rise abruptly from the plains to great altitudes (estimated at 10,000 to 12,000 feet, or even higher, but there is no absolute determination of the height of any of the most prominent peaks) and assume a general formation of parallel ranges, with a strike from north-west to south-east, sheltering lateral valleys, which are wide and fertile, highly cultivated, and teeming with agricultural wealth. It is here that coffee and indigo are chiefly grown. Here, in Arabia Felix, English vegetables and many kinds of fruit reach perfection in a climate of which the average mean shade temperature may vary between 60° and 70° F. A line drawn from Aden northwards for 170 to 180 miles will pass not very far from the main water-parting of the plateau, of which the average level is 7000 or 8000 feet, and not far east of the great caravan road which connects Sanaa, the capital of Yemen, with the great southern port. It is on this route that the towns of Ketaba, Terim, and Damar are situated, and it has probably been through all ages the great central trade-route of Yemen. It is remarkable that whilst the Teháma is subject to a most uncertain rainfall, there should be two regular wet seasons in the highlands, corresponding to the spring and autumn "monsoons" of Harrar and the Galla country. Rain is said to fall daily during the recurrence of these wet seasons, but with intermittent periods of bright sunshine. Of the beauty of the scenery in the Yemen hill-country, Harris gives us a most vivid description. "Torn into all manner of fantastic peaks, the rocky crags add a wildness to the view that otherwise possesses the most peaceful charms. Rich green valleys, well timbered in places, and threaded by silvery streams of dancing water; sloping fields gay with crops and wild flowers; the terraced or jungle-covered slopes—all are so luxuriant, so verdant, that one's ideas as to the nature of Arabia are entirely upset." Colonel Wahab, who surveyed the hills north of Lahej in the Aden district, describes the wealth of green terraces, sloping in steps of graceful contour down the spurs of the mountains, as recalling the beauty of Himalayan scenery in the valleys of the Jumna and Sutlej. *Sanaa*, the capital of Yemen, lies at an elevation of nearly 7800 feet above sea-level, about 250 miles by road to the north of Aden, and 180 by road north-east of Hodeida, on the Red Sea coast. Between Sanaa and Aden are the three principal towns of Damar, Terim, and Ketaba, the last marking the southern frontier of Turkish occupation in the highlands. *Damar*, 9300 feet above sea-level, is described by Harris as being an unwalled town, but protected by small mud forts placed at intervals—an obviously Turkish innovation denoting recent construction. Many of its houses are well built of stone, and decorated with considerable taste. A peculiarity in their construction is the use of slabs of alabaster for the windows, which, being carved in relief, admits of a peculiarly soft and varying light. There is an open square about the centre of the town, the bazaars and narrow streets around it being full of life and busy with trade. As usual, the Jews occupy a separate quarter. The effects of Turkish misrule are everywhere strongly marked in Damar. *Terim*, 80 miles from Sanaa, is comparatively a new, and essentially a poor, town, built chiefly of sun-dried bricks. It lies between 7000 and 8000 feet above sea-level.

Two notable examples of the engineering skill of the Sabæan and Himyaritic Arabs exist in Yemen: one at Hirran, near Damar (which Harris believes to be the Haran of Biblical record), and the other at Mareb or Saba. The storage tanks at *Hirran*, which are supplemented by deep wells, were obviously built for the purpose of providing water for the garrison of an ancient fortress which encloses them. Two spurs of a hill have been joined by an enormous wall, whereon there is space sufficient to drive "a carriage and pair." This wall is 150 yards long and 20 feet high, and is built with the peculiar cement which is typical of early Arab construction. Harris recognized in it many points of similarity to a gigantic wall, dating from early Arab times, which exists at Mekinez in Morocco. Within the wall is a well of which the lower part is sunk in the solid rock, and above the northern end are a series of three tanks reached by a stairway. Hirran, or Hail Hirran, as the hill is also called, is perforated with excavations, and abounds in sepulchral ruins and masses of broken pottery. The great dam of *Mareb* (*Sheba* or Saba) possibly dates from 1700 years B.C., for its construction is attributed to the father of Himyar, the founder of the Himyaritic dynasty. It is certainly of vast antiquity. M. d'Arnaud describes its ruins as comprising a gigantic wall 2 miles long and 175 paces wide, connecting two hills. The water which was stored by means of this enormous dam was allowed to escape by dykes, or openings, at different levels, so that irrigation could be maintained, no matter at what level the water of the tank might stand. It is supposed to have been burst under exceptional pressure about A.D. 100.

The system of storing water in tanks, and the evidences of its antiquity, are abundant throughout South Arabia, and these evidences may supply a key to the mystery of those strange constructions in Southern Baluchistan and Makrán which for ages have presented an interesting problem to investigators. Throughout Makrán, but perhaps more especially in the districts of Panjgur and Kolwah, there are relics of walls of enormous thickness, and sometimes of considerable height, which are only known to the local inhabitants as Ghorbasta, or Ghahrbasta, the name indicating merely that they were built by a race of sun- or fire-worshippers. No modern Baluchi acknowledges any connexion with them. They possess, in fact, no history—no tradition even; but the peculiarities of their construction distinctly point to the same race of people for their origin as those who terraced the hillsides and revetted the fields round about them with similar masonry.

Those "Asiatic Ethiopians" whom Herodotus places in Southern Baluchistan 500 years B.C. have disappeared, and the Arab influences which now pervade the country from end to end are of later date and different origin; but there can be little doubt that the Sabæan or Himyaritic races of dusky Arabs who fenced round their gold mines in Africa with strange fortifications and built up the vast protective works for water storage in South Arabia, are responsible for many works designed on the same principles and of similar construction on the eastern side of the Persian Gulf. (See BALUCHISTAN.)

A certain amount of fresh light has been thrown on the ancient connexion between Ethiopia and South Arabia by the researches of Glaser. This connexion was evidently so close as to approach to the affinity of blood relationship. Egyptians, Syrians, and Greeks traded with Arabia for frankincense for more centuries before our era than we can clearly count. "In the most primitive times," says McCrindle, "the merchants of Arabia traded to Gaza and Egypt, and the producers of incense in Africa followed their example." What the Greeks called Ethiopia the Egyptians called Punt (or Pwent), Habash, and Kash. Punt certainly referred to both sides of the Red Sea, but the name never occurs in Himyaritic inscriptions. Habash (or Habashat) does occur, and, according to Glaser, the word means "collector"—*i.e.*, collector of incense, and applied equally to Africans and Arabians—to Abyssinia and Somaliland as well as to Hadramut.

Arab history.

The condensed history of the Arab nation from the very earliest ages, which is to be found in the articles "Arabia" and "Yemen" of the ninth edition of the *Encyclopædia Britannica*, sufficiently illustrates the expansion of Arab trade and Arab colonization in those days when Ethiopia and Southern Arabia seem to have been united in the closest bonds of commercial affinity, and gold and frankincense and myrrh formed the chief articles of commercial quest. But whilst the spread of Arab (or Himyaritic) influence to the west and north can be more than faintly estimated from classical records and ancient inscriptions, there is very little said about eastern fields of enterprise, and it is only since the waste places of Baluchistan and the shores of Makrán have been brought under the close scrutiny of the Indian surveyor that evidence has been collected which proves that Arab enterprise, if not Arab empire, included a vast area of Asia to the east of the Persian Gulf, just as it included a vast area of Africa to the west of the Red Sea.

Herodotus refers to Asiatic Ethiopians, but makes no confusion between Africa and Asia as some modern historians suggest. The historians of Alexander's campaigns throw a casual light on the existence of a trade in incense which could only have been carried on by Arab merchants. In enumerating the inhabitants of Southern Gedrosia (Baluchistan), Ptolemy mentions Arbitæ, Parsidæ (or Parsiræ), and Rhaminæ, whose names are too suggestive of the Arab, Persian (or Tajak), and Dravidian ethnic occupation of the same nature that now exists to be altogether accidental. But it is to that invaluable anonymous record, the Periplus, and to the discovery of many relics of the ancient trade in Egyptian or Phœnician glass (the Ὕαλος ἀργή of the Periplus), which are to be found in abundance on the coast of Makran, that we are chiefly indebted for the identification of many of the trading ports of the Arabian Sea which would otherwise be subjects of conjecture.

Long before the rise of Mahommed, Semitic colonies had planted themselves in Asia to the east of the Persian Gulf, and from the days (early in the 1st century of our era) that the pilot Hippalus worked out the problem of a regular passage between India to Africa by making use of the monsoon winds, Arabia competed with Egypt on the commercial highways of the ocean. The *Christian Topography of the Universe*, by Cosmas Indicopleustes (about A.D. 535-547), continues the story of the Periplus about 400 years later, and gives an account of the trade with Malabar and the Eastern Archipelago, which is taken up again by Arab geographers of the next seven centuries. A trading colony of Sabæan Arabs existed at Canton at the beginning of the 7th century. Arabian science influenced Chinese astrology, meteorology, and astronomical instruments, according to a learned Chinese authority. Colonies of Arabs and Jews settled early in our era on the southern coasts of Bombay, where their descendants are to be found to this day. When Mahommedan Arabs resorted thither in after ages they met with a friendly reception similar to that which their Sabæan predecessors had obtained, and they shared the honoured name of Moplah together with Christians.

With the rise of Mahommed and the universal acceptance of the creed of Islam, the second chapter in the history of Arabia opens. Hitherto Semitic instincts for trade and barter had been the moving spirit of an extension of Semitic, if not of Arab influence over the whole of the then known world. It was the enormous acquisition of geographical knowledge, supplemented by commercial wealth—the accumulation of centuries of trade, initiated no doubt by the southern or Himyaritic races, but gradually shared by the northern or more distinctly Semitic tribes—that paved the way for the unprecedented success of Arab arms in the cause of "Jehad" or holy war. The chief military movements directed against Europe, Northern Africa, and Persia, under the influence of Islamitic religious fervour, and the almost unbroken success which attended these movements, are already briefly recorded. But in this record no note is made of that most remarkable episode in Arab history which culminated in the conquest of Sind, stamped out Greek influences on the Indus, and proved to be the one occasion in history when India was successfully invaded from the west. Very early in the Mahommedan era, if not before it, Arabs from the north—*i.e.*, from Syria—had overrun and occupied Makrán and Sistán. Several attempts to invade India were made before the successful expedition of Mahommed Kasim in A.D. 710. According to latest history (Major Jarrett's translation of Az Siyuti), Makrán was subjugated in 644, and in 663 Kirmán, Sistán, and the western mountain districts of Makrán were conquered. Two attempts to capture Debal, the port of Sind, were unsuccessful. In the Caliphate of Moawiah, Abdulla bin Suwad invaded Kaikanan (*i.e.*, the Kelat highlands) and attempted to reach Sind that way; but the attempt failed, and there may still be seen near Kalat the traditional graveyard of the Arabs who fell in the attempt. Frequent Arab incursions were made Indiawards, but they were all by land following the Kirmán and Makrán route from Syria. Buddhism, which prevailed all through Sind and the mountainous districts to the west, had given place to Brahmanism about the middle of the 7th century, when the Brahman Chach usurped the throne of Sind. But it still held its own in Bela, between Sind and Makrán, and in the border province of Gandava (sometimes called Kandahar by Arab geographers), which was known as Budh at the beginning of the 8th century. There were great Arab cities and a flourishing trade between east and west before the Arabs conquered Sind. Kandabel (Gandava), Armail (Las Bela), Kanazbun (Panjgur), were certainly in existence before Sind was conquered, and it is probable that many of the other towns and cities of Makrán which subsequently rose to fame and opulence, when the great trade route to India passed through that country, were already founded, if not already famous.

The Sind invasion.

The conquest of Sind originated in the efforts of Walid (sixth Caliph) to punish the Karak and Med pirates who had plundered vessels from Ceylon laden with presents for the Caliphate. These Karaks (who have left their name at Karachi) were of Scythic origin, and their ethnic affinities may be traced on the Euxine to this day. They have disappeared from the coasts of Baluchistan. The Meds are still there, a humble and starved race of fisher folk now, but once a powerful tribe in the Punjab and on the Indus. They, too, hailed originally from the north. Thus the expedition finally became partly military and partly naval; and it appears to be the first Arab naval expedition in the eastern seas, although they were about the same time occupied in the conquest of Spain from the shores of Africa. It was not until two unsuccessful attempts had been made to reach Debal that Hajjaj, the governor of Irak and Makrán, appointed his relative, the boy-general Mahommed Kasim, to the command of a fresh force, with the conquest of Sind in immediate view, but with the ulterior object of reaching China from the Indus. At the same time another general, Kotaiba, left the Oxus for the same goal, and the governorship of China was promised to whichever of the two reached that country first.

With a force of 6000 picked cavalry, 6000 camel-men, and 3000 baggage animals, Mahommed Kasim traversed Makrán, sending at the same time five catapults by sea for the purpose of reducing Debal. He passed through Makrán from west to east, destroying the Buddhist city of Armail (Las Bela) *en route*, and finally captured Debal on the 1st May 712. From that point his onward progress was triumphant. He enlisted Meds and Jats into his army, and by the time he had reduced Sadusan (Haidarabad) and reached Multán he had 50,000 men under him. He extended his conquests northward to the borders of Kashmir, and established an Arab dynasty in Sind which lasted for three centuries. The Caliph Walid died in 715 (after substituting Arabic for Greek as the language of the Indus provinces), and the tragic end of Mahommed Kasim is one of the epics of Arab history. These three centuries of Arab occupation of the Indus valley mark the zenith of Arab ascendency in Asia. In 770 the governor of Sind became governor of Africa, and again in 800 there was a similar transfer. Amran was perhaps the most famous governor. His control of Sind lasted from 833 to 841. Before the end of the 9th century Arab rule had commenced to decline; and then arose the cities of Multán and Mansura.

Throughout these centuries Sind maintained regular commercial communication with the rest of the Mahommedan empire; with the regions of the upper Oxus by way of Kabul and Bamian; with the Central Asian khanates through Zabulistan, Kandahar, and Herat; with Persia and Syria and Europe through Makrán: and a host of Arab geographers arose who have partly recounted their own experiences as travellers, and partly (as in the case of the best known of them, Edrisi) acted as geographical compilers. From them we learn the enormous extent of that vast network of commercial routes which was then spread over the face of Asia—a system of roads, caravanserais, and mercantile centres which has left its traces plainly written in spite of the sweeping waves of destruction poured across it by Moghul and Tatar. The skeletons of ancient towns and the dry channels of great irrigation works in the valley of the Helmund and the plains of Sistán witness to the former wealth of these regions under Arab rule; and from Quetta to Herat, and from Herat through Badghis and Afghan Turkestan to the Oxus, there are still to be encountered evidences of Arab occupation in acres of ancient ruins.

One or two of their more famous cities may be mentioned. Tiz, now a heap of ruins and a waste of graveyards on Chahbar bay, was once a great port of debarkation on the Makrán coast for India. It is well situated so as to avoid the full blast of the monsoon winds across the Arabian sea. From Tiz to the fertile valley of Kiz (or Kej), and from Kej to Kanazbun (Panjgur), Armail (Las Bela), Manhabari (Manja, or Mugger, Pir), and Debal, the ancient Indus port (the ruins of which are now far inland), the most frequented of these trade routes extended its length. Kiz and Kanazbun are described as large cities—as large as Multán; and the merchants of Kanazbun were famous for their wealth and their fair dealing. In the Indus valley such cities as Sadusan, Mansura, and Brahmanabad outrivalled the glories of any of our modern Indus towns.

Arabia as a naval power.

It was doubtless during these three centuries that the Arabs developed their genius for shipbuilding and acquired that command of the eastern seas which was followed by the complete domination of the Mediterranean. As traders, Semitic races had held their own on the seas from the earliest dawn of history, and although they fell before the naval power of Rome, they reasserted themselves in full force, as Saracens, during the Middle Ages, even in the West. In the East they struggled long for supremacy with the Turks and finally lost it, but they were the first sea-power on the Indian Ocean and in the Persian Gulf. The lines they originally laid down for the construction of their sea-going vessels may be as distinctly traced in the early ocean sailing ships of Portugal, Spain, Holland, and England, as their nautical terms and astronomical nomenclature may be found in the mouth of the modern sailor. Many naval terms and nearly all the astronomical divisions of the heavens are of Arab origin. During the sovereignty of the early Caliphs an immense impetus was given in the Baghdad schools to the study of mathematics and the exact sciences. Borrowing their numerals from India and the compass (as well as gunpowder) from China, the Arabs had evolved for themselves systems of navigation and instruments for determining the value of latitude and longitude, before the close of the 12th century. About the time that Roger, king of Sicily, employed the geographer Edrisi in the compilation of a geographical map of the world, Abdul Hassan Ali of Morocco wrote a treatise on astronomy which included a detailed account of the use of instruments already well known and in the hands of Arab navigators. Amongst them was that ingenious instrument the astrolabe, by means of which observations for latitude could be obtained. Longitude was determined then, as now, by the differences between clock and sun time. It seems, indeed, almost incredible that the route to India *viâ* the Cape of Good Hope should have been left to Portuguese navigators to discover; for the Arabs certainly knew how to traverse the Indian Ocean centuries before the arrival of Vasco de Gama. It is possible that that great Portuguese adventurer made use of Arab pilots in his voyages of discovery. With the rise of schismatics and the birth of those heresies which, under the name of Khariji, Khesaja, Shariite, Ismailite, Karmatian, &c., spread their roots afar from Syria to Mecca and from Mecca to the Indus, the power of the Arab in the East rapidly waned. Chief amongst these sects were the Karmatians. We hear of them first in the days when the power of the Caliphate was declining, ere the reign of Al Muktadar (908-932), by which time the Turks were already aggressive. By then the Karmatian heretics had brought themselves into prominence by plundering Kufa, Basra, and Samara, and even carried off the sacred stone from Mecca. They are not mentioned by Ibn Haukel as being in the Indus valley in the 10th century, but it could not have been long afterwards that they appeared as refugees from Bahrein and El Hasa. About 985 they founded new settlements on the Indus, and shortly afterwards were in possession of Multán and Mansura. Mahmud of Ghazni captured Mansura, about 1036, on his return from Somnat, being already in possession of Khozdar (Kalat) and Multán, and thus practically closed the era of Arab ascendency in Sind. He restored the old mosque at Multán, built by the Ummayide Caliphs and destroyed by the Karmatians. There is a peculiar interest attaching to these "people of the veil," for they were in close communication with the mediaeval schismatics of Syria, the Hashashin, the Ismailites, the Druses, and others of those mystical sects who were indebted to the East for their philosophy and theology and those mystic creeds which ended in pure atheism. The Ghazni rule did not last long. It was soon replaced by the Sumra dynasty of Mahommedan Rajputs, which lasted for three centuries. One of the Sumra rajahs at least was a Karmatian. Pure-bred Arabs had almost disappeared from Sind ere the rise of the Karmatians. It is said that the first Ghaznivide governor of Multán found but very few Arab families remaining; but Baluchistan still continued to attract them, and although the Arabic tongue has disappeared from the regions east of Persia, there is not a tribesman who boasts the title of "asl" or "pure" Baloch, who does not claim Arab descent and associate his ancestry with the tribe of Khoreish. In many cases this claim is obviously without foundation, but there is still a powerful confederation of tribes calling themselves Rind, whose appearance, manners, and traditions are undoubtedly Semitic. They exist in the lower parts of the Kej valley of Makrán, separated by the country of the Brahui from the Indus border Rinds, who occupy the highlands south and east of Quetta under the name of Marris, Bugtis, Bozdars, &c. The Arab tribes (or tribes of Arab extraction) on the Baluch borderland include the best and finest amongst the many peoples of varied origin who occupy positions of independence in the frontier hills.

There is but little to record of evidences in stone and brick of the Arab conquest of Sind. Long lines of tombs, stone-built and massive, are to be seen at Tatta, all of which are of Mahommedan design, but probably of later date than the days of Mansura and Brahmanabad. The best known and the most interesting relics are the curious double-chambered tombs (the two chambers forming a double storey), richly ornamented with geometric designs, and decorated with the true Saracenic arch, which exist in groups throughout southern Sind and the Las Bela borderland. They always exist apart from the visible remains of destroyed cities, being themselves often in a remarkable state of preservation, and conspicuous objects in the landscape by reason of the elevated sites which have been selected for their building. These are attributed to an Arab race called Kalmati, who are said to have originally migrated through Makrán from Oman and who, in the course of their migration, settled on the shores of the Kalmat Khour, one of the harbours of the southern coast near Pasni. The name Kalmat is so old as to be recognized as the "Kalama" of Nearkos; so that it is probable that the comparatively recent tribe of southern Arabian origin who, under that name, formed a powerful community in southern Sind within historic times, and have left behind them by far the most perfect Arab monuments to be found on the borders of India west of the Indus, adopted the name of their temporary resting-place in Makrán. Scattered remnants of the tribe are said still to be found in Sind.

Recent history.

Turkish sovereignty is now paramount through all Western Arabia, from Palestine to the strait of Bab-el-Mandeb, as well as through Eastern Arabia, from Basra, on the Euphrates, to the boundaries of Oman. The cultivated districts of the southern coast are divided between British occupation and that of independent tribes; the central deserts are still the home of the Beduin; and the highlands of Nejd are divided between two independent chiefships, each of which is of doubtful territorial extent, but considerable political significance.

The condition of Arabia about the middle of the 19th century, when the Wahabi stretched his rule across the peninsula from the Red Sea to the Persian Gulf; when Hasa, Harik, the whole of Nejd, Kasim, Asir, and the provinces adjoining Yemen on the north were united under the sceptre of Feysul, has been well described by Palgrave. In 1870 Feysul, aged and blind, was assassinated, and dissensions arose which led immediately to the decline of Wahabi power, and gave opportunity to the Turk. A Turkish force was despatched into the province of Hasa on the east, and occupied its capital, Hofhuf; and about the same time Turkish interference asserted itself on the west in Asir (between Yemen and Hejaz), and in the inland provinces of Shammar. In 1871 a Turkish army from Syria tentatively established Ottoman sovereignty in Yemen, at the invitation of the Yemenis themselves; but Palgrave considered (with good reason at the time he wrote) that Yemen would not remain long under Turkish rule. The Turks have, however, not only retained their hold on Yemen, but they have rather consolidated than weakened their authority in the Shiah province of Asir, and extended it indefinitely into the hinterland which borders the central desert on the east of Yemen. In Hejaz their authority has never been doubtful, so that all the fertile and populous districts of Western Arabia bordering the Red Sea are now under Ottoman rule; and this rule is only limited on the south by the British occupation of Aden and the consequent extension of British influence into the adjoining districts. No definite boundaries exist; but the southern frontier of Turkish Arabia is placed by the most authoritative maps in a position a little to the south of Kataba. Kataba is about eighty miles due north of Aden, well within the limits of the mountain districts, which here attain to altitudes of 7400 and 7700 feet above sea, as determined by the latest Indian surveys. From a point south of Kataba, which roughly forms the apex of the triangular division of Southern Arabia included within Aden jurisdiction, the partition line between Turkish Arabia and the Aden districts runs irregularly past Tez (a town south of Ibb on the main northern caravan route) to a point on the coast line of the promontory of Sheikh Said, about seventy miles to the west of Aden. Here the Turks have constructed a fort and established a permanent military post at Turba. The guns of the fort do not command Perim, and the object of the occupation is doubtful. It is to this position that the French have advanced a shadowy claim. On the east the division between Aden and Yafi territory reaches from Kataba to the coast, near Shukra, about sixty miles east of Aden. From this point to the borderland of the fertile province of Oman, which occupies the south-eastern corner of the peninsula, the cultivated and habitable districts of the southern coast are under the independent rule of local chiefs who boast (according to Palgrave) an independence of barbarism and poverty which is in great contrast to the organized and progressive governments of the Arab sheikhs of Central Arabia. This hardly agrees with the latest illustration of the conditions of Arab existence in Hadramut afforded by the explorations of Bent. Hadramut is in direct touch with civilizing influences at Haidarabad in the Deccan of India; and in that city many of its chiefs are to be found serving the Nizam. Indigenous Arab government, undisturbed by Ottoman rapacity or by internal dissensions, invariably demands respect. In Southern Arabia, at the present time, it is probably to be found at its best. The province of Oman has always succeeded in maintaining its independence of Turkey, and is now under the rule of a member of the same Yemenite dynasty of Imams that has existed since the province was first delivered from the yoke of Persia, about the middle of the 18th century. The Turks are as firmly established in El Hasa, to the north of Oman, as they are in Hejaz, in Western Arabia. Hofhuf, the capital of El Hasa, is about 40 miles from Ajer, on the coast, and from 90 to 100 from Katif. Here, and at El Bidia, is a small garrison of regular Turkish troops. At Katif, where there is nothing but an old fort facing the sea, a force of zaptieh (Turkish gendarmerie) represents Ottoman authority. El Hasa is governed by a Turkish lieutenant-governor under the Wali of Basra. In 1886 the Turks commenced the construction of a fort at Fao, nearly opposite Mohamrah, on the lower Euphrates, which effectually dominated the channel of that river. This was in direct contravention of their treaty engagements with Persia. In consequence of representations made to the Porte by the British Government, the work was suspended some years ago, and guns were never placed in position; but the *enceinte* of the fort remains exactly as first constructed. In the Nejd or highlands of Central Arabia the political divisions of the country are represented by two independent Arab states, governed by the emirs of Jebel Shammar and Riad respectively. Ibn Rashid of Jebel Shammar, lately deceased, was reckoned to be the most important political personage amongst Arab chiefs of the present day. He was said to possess a bodyguard of 1000 mounted negroes, whose steeds were arrayed in silver harness. He was undoubtedly a strong and capable ruler. The two emirs or sheiks are independent of each other; but both admit Turkish influence, whilst they repudiate Turkish sovereignty. The Turks themselves, for political reasons, still include all the Wahabi territory which they once dominated under the term Nejd in their official documents, and they maintain their nominal rights as conquerors over the country. Practically, they do not interfere with the local Arab governments, which appear to be strong, progressive, and equitable.

The Yemen rebellions.

Turkish authority in Yemen has never been established on the firm basis which supports it in El Hasa and Hejaz. Turkish misrule and oppression have, no doubt, much to answer for in promoting the rebellions and disturbances which, with but intermittent periods of rest from exhaustion, have harassed Yemen since 1891. But it must be remembered that the province of Asir, north of Yemen, in which these rebellions commenced, is a Shiah district, allied by religious principles to Yemen rather than to the orthodox province of Hejaz, and that there are some 600,000 Wahabis, as well as upwards of 2,000,000 Shiites in Yemen who do not recognize the Caliphate of the sultan in any way, and who will always dispute Ottoman sovereignty when an opportunity may arise which promises success. The easy and slack government of the Shiah Imam of Yemen had terminated in something approaching to general anarchy in the country in 1871, when the Yemenites rashly invited Turkish intervention. The Turks came from Hodeida, and, *more suo*, they came to stay. Although the Imam survived the Turkish occupation of Sanaa, the capital of Yemen, he existed only as a Turkish pensioner, and the Arab tribespeople soon found themselves little better than Turkish slaves. Acts of oppression and violence on the part of the Turkish authorities led to a revolt which commenced with resistance to tax-collecting on the part of an Asir tribe, the Beni Meruan, in 1891. Turkish rule had never been more than nominal in Asir, and so long as the Beduin rulers of Hejaz withheld their support it was of no great political significance. But the first reverse sustained by the Turkish troops (who took the field unprepared, and were defeated with a loss of 400 men in the early stages of the rebellion) set all Yemen aflame, and in a very short time the insurrection included all tribes south of Asir, excepting the Beduin of the Tehâma. A Turkish force which landed at Hodeida under Ahmad Feizi Pasha—formerly governor of Mecca—checked its progress for a time. Manakha was retaken, Sanaa relieved, and Ismail Pasha was despatched to crush the rebellion in the south. Here a rapid collapse of the insurrection ensued, and, with 40,000 Turkish troops in Yemen, it appeared in 1893 as if resistance was at an end. The northern mountain districts, however, were but half subdued, and with but small provocation the flame has burst out again and again with intermittent persistency ever since. In May 1895 the British vice-consul was murdered. Early in 1896 fighting between the Ateybe and Harb tribes was reported; and the disturbances culminated with a partially successful assault upon Yambo (where the governor was wounded in the conflict) and in a mutiny at Jidda. It was decided to build forts at Jidda, and to despatch further reinforcements; but the record of the next two years still continued to be one of local disturbance throughout the country, and of more or less organized rebellion in certain parts of it. The plundering propensities of the Wali, and the unrest which is the invariable sequel of famine, led to another serious rising in 1899, and to the despatch of 22,000 troops and 7 batteries of artillery from Mecca. In May 1899 the Turks suffered a severe reverse at the hands of the Beduin, led by the Imam; but another hard-fought battle took place in June, in which the Turks were successful. In October of the same year 35 regiments, each 400 strong, left Constantinople for Upper Yemen; and since then, although, according to report, there have been intermittent fighting and active rebellion from time to time, it is clear that on the whole the Turks have not only maintained their position but have annexed new country and extended their occupation to the eastern hinterland of Yemen. Turkish occupation has doubtless favoured the interests of Great Britain in Yemen by affording some sort of guarantee for the safety of trade routes. The greater part of the Yemen trade now flows to Aden. The anarchy which preceded Turkish rule affected not only local trade but the importation of European goods from the Persian Gulf.

Trade.

As might be expected from the close connexion which exists between commercial Arabia and India, trade prospects have suffered considerably from the influences of famine and plague of late years. The Jidda trade in 1897 showed a falling off of nearly £51,780 (or 8 per cent.), reducing the total import value to about £645,000. On the other hand, trade with Egypt (which, curiously enough, includes the importation of a considerable amount of Brazilian coffee) is increasing rapidly. The chief imports are rice, wheat, and manufactured goods. The decrease in the value of the latter alone amounted to £35,740. Exports (chiefly hides, gum, and mother-of-pearl) also show a decrease, the total value only amounting to £19,250. Hodeida has suffered equally from the general depression of trade, although the want of a harbour must be reckoned as a permanent drawback to trade with this port. The total imports (piece goods, food stuffs, spices, and dates chiefly) were valued in 1897 at £705,200, and the exports at £712,660. The latter are mostly coffee and hides, the value of the coffee export alone being over half a million. The products of Yemen are almost exclusively agricultural. Coffee, dates, vegetables, and fruit from the hills, with rock-salt, iron, and coal from the Tehàma and lowlands, are the chief items in the trade reports, the lowland productions being inconsiderable. The Yemenis (estimated at 3,000,000 souls) weave a kind of coarse cloth, and they dye American cloth goods, and build ships; but they have apparently no other industries. Eastern Arabia contributes something to the trade of the Persian Gulf. Bahrein is answerable for an export of nearly half a million in value, and an import of £550,000. The former includes dates, rice, pearls, and specie as the principal items, the value of the pearl export in 1898 being nearly £300,000. The imports include coffee, dates, piece-goods, rice (in large quantities from India, and of the very best quality, much of which is exported to the mainland), pearls, and metals. Of the total export value of £387,000 from the Arab coast ports in 1898, £357,700 worth went to Persia, and of that amount £343,750 is included under the head "pearls." This indicates that Linja, on the Persian coast, is the great trade mart for pearls of the Gulf; and that Arab trade, independently of this valuable item, is inconsiderable. The rice trade with India is that which figures most largely in the general commercial record of trade with ports outside the Gulf, and this, no doubt, is important. (For Aden trade see ADEN.)

AUTHORITIES.—ZEHME. *Globus*, vol. xxii. xxiii. xxiv.—BLUNT, W. S. "A Visit to Jebel Shammar," vol. ii. *Proc. R. G. S.* 1880.—BLUNT, LADY ANNE. *Pilgrimage to Nejd*. London, 1881.—MÜLLER, H. Al Hamdani's *Géographie*. Leiden, 1884.—DOUGHTY, C. M. *Documents épigraphiques récueillis dans le nord de l'Arabie*, Paris, 1884; *Travels in Northern Arabia in* 1876-77, Cambridge, 1886; *Travels in Arabia Deserta*, Cambridge, 1888.—BENT, THEODORE. "Bahrein Islands," vol. xii. *Proc. R. G. S.* 1890; "Southern Arabia," vol. vi. *Geog. Journ.* 1895; "Hadramut," vol. iv. *Geog. Journ.* 1894.—MILES, Col. S. B., "Coasting Journey along Southern Arabia," vol. viii. *Proc. R. G. S.* 1886; "Journal of an Excursion in Oman," vol. vii. *Geog. Journ.* 1896.—HAIG, General F. T. "A Journey through Yemen," vol. ix. *Proc. R. G. S.* 1887.—SCHWEINFURTH, Dr. G. *Exploration géologique de l'Ouadi Arabath*. Cairo, 1888.—WALTHER, Prof. J. "The Geology of the Sinai Peninsula and Arabian Desert," vol. x. *Proc. R. G. S.* 1888.—GLASER, ED. "Journeys in Arabia," vol. xi. *Proc. R. G. S.* 1889.—DEFLERS, A. "Voyage en Yemen." Paris, 1889.—HUBER, CH. "Journal d'un voyage en Arabie." *Société Asiatique*. Paris, 1891.—KAY. *Omarah's History of Yemen* (translation). London, 1892.—HARRIS, W. *A Journey through the Yemen*. Edinburgh, 1893.—HIRSCH. "Bericht über seine Reise nach Hadramot," *Verh. Ges. Erdk.* xxi. Berlin, 1894.—NOLD. "Reise nach Inner-Arabien," *Globus*, lxvii. 1895.—COURTELLEMENT. "Un voyage à la Mecque," *B. S. G.* xiii. Lyon, 1895.—SIEDEL. *Arabic Languages*. Vienna, 1894; London, 1895.—HOLDICH, Sir T. "Ancient and Mediæval Makran," vol. vii. *Geog. Journ.* 1896.—STIFFE, Capt. A. W. "Ancient Trading Centres of the Persian Gulf," vols. vii. ix. and x. *Geog. Journ.* 1896.—EUTING. *Tagebuch einer Reise in Inner Arabien*. Leyden, 1896.—ROSSI, G. B. L'Iemen avanti il profeta," *Rassegna nazionale di Firenze*, 1897.—LAUSSEDAT. *Recherches sur les instruments et les méthodes topographiques*, vol. i. Paris, 1898.—LANDBERG. "Arabica," No. v. *Leiden*, 1898.—CHARNAY. "Une excursion au Yemen," *B. S. R. G. d'Anvers*, xxiii. 1899.—BURTON. "Pilgrimage to Mecca" (unpublished MS.), *T. R. S. Literature*, xx. 1899.—DEFLERS. *Tour du Monde*.—ZWEMER, *Arabia the Cradle of Islam*. Edinburgh, 1900. (T. H. H.*)

Arabistan, formerly known as Khúzistán, a province of Persia, bounded on the S. by the Persian Gulf, on the W. by Turkish territory, on the N. by Luristán, and on the E. by the Bakhtiari district and Fars. It is now subdivided into the districts of Muhamrah (*q.v.*), Fellahíyeh (the old Dorák), Rám-Hormuz (popularly known as Rámiz), Havizeh, Shushtar, and Dizfúl, has a population of about 200,000 (mostly Arabs), and pays a yearly revenue of about £30,000. The soil is very fertile; but since the dam over the Karun at Ahvaz was swept away, and the numerous canals which diverted the waters of the Karun and other rivers for irrigation were neglected and became useless, a great part of the province is uncultivated, and most of the crops depend for water on rainfall or the overflowing of the rivers.

The district of SHUSHTAR, with the city of same name, 22 villages, and about 3700 families of the Kunduzlú, Sád, Anafijeh, and Al-i-Kethír tribes, has a population of about 40,000, and pays a yearly revenue of about £6000. The city, with a population of about 15,000, is situated at an elevation of 400 feet at the point where the Karun river bifurcates into the Ab-i-Gerger and Shutait, in 32° 3′ N. lat. and 48° 53′ E. long.

The district of DIZFÚL, with the city of same name 12 villages, and 1000 families of the Al-i-Kethír tribe, has a population of about 40,000, and pays a yearly revenue of about £6000. The city has a population of about 25,000, and is situated on the *left* bank of the Ab-i-Diz at an elevation of 600 feet in 32° 25′ N. lat. and 48° 28′ E. long. (A. H.-S.)

Arabkir, a prosperous town of Asia Minor, in the Memuret ul-Áziz, or Kharpút vilâyet, situated on an elevated plateau, near a small tributary of the Euphrates. Its large Armenian population suffered severely during the massacres of 1895. Population, before 1895, 20,000 (Moslems, 11,000; Christians, 9000).

Aracaju, a city and port of Brazil, capital of the state of Sergipe. The town was founded in 1855, and has now a population of about 10,000. It has a hospital, high school, normal school, a number of churches, and other public buildings.

Aracaty, a town and port of Brazil, in the state of Ceara, with a population of 18,000. It is an important commercial centre, visited by several lines of coastwise steamers.

ARACHNIDA.

ARACHNIDA is the name given in 1815 by Lamarck (Greek, ἀράχνη, a spider) to a class which he instituted for the reception of the spiders, scorpions, and mites previously classified by Linnæus in the order Aptera of his great group Insecta. Lamarck at the same time founded the class Crustacea for the lobsters, crabs, and water-fleas, also until then included in the order Aptera of Linnæus. Lamarck included the Thysanura and the Myriapoda in his class Arachnida. The Insecta of Linnæus was a group exactly equivalent to the Arthropoda founded a hundred years later by Siebold and Stannius. It was thus reduced by Lamarck in area, and made to comprise only the six-legged, wing-bearing "Insecta." For these Lamarck proposed the name Hexapoda; but that name has been little used, and they have retained to this day the title of the much larger Linnæan group, viz., Insecta. The position of the Arachnida in the great sub-phylum Arthropoda, according to recent anatomical and embryological researches, is explained in another article (ARTHROPODA). The Arachnida form a distinct class or line of descent in the grade Euarthropoda, diverging (perhaps in common at the start with the Crustacea) from primitive Euarthropods, which gave rise also to the separate lines of descent known as the classes Diplopoda, Crustacea, Chilopoda, and Hexapoda.

Limulus an Arachnid.—Modern views as to the classification and affinities of the Arachnida have been determined by the demonstration that Limulus and the extinct Eurypterines (Pterygotus, &c.) are Arachnida; that is to say, are identical in the structure and relation of so many important parts with Scorpio, whilst differing in those respects from other Arthropoda that it is impossible to suppose that the identity is due to homoplasy or convergence, and the conclusion must be accepted that the resemblances arise from close genetic relationship. The view that Limulus, the king-crab, is an Arachnid was maintained as long ago as 1829 by Straus-Durkheim (1), on the ground of its possession of an internal cartilaginous sternum—also possessed by the Arachnida (see Figs. 1, 2, 3, 4, 5, and 6)—and of the similarity of the disposition of the six leg-like appendages around the mouth in the two cases (see Figs. 45 and 63). The evidence of the exact equivalence of the segmentation and appendages of Limulus and Scorpio, and of a number of remarkable points of agreement in their structure, was furnished by Lankester in an article published in 1881 ("Limulus an Arachnid," *Quart. Journ. Micr. Sci.* vol. xxi. N.S.), and in a series of subsequent memoirs, in which the structure of the entosternum, of the coxal glands, of the eyes, of the veno-pericardiac muscles, of the respiratory lamellæ, and of other parts, was for the first time described, and in which the new facts discovered were shown uniformly to support the hypothesis that Limulus is an Arachnid. A list of these memoirs is given at the close of this article (2, 3, 4, 5, and 13). The Eurypterines (Gigantostraca) were included in the identification, although at that time they were supposed to possess only five pairs of anterior or prosomatic appendages. They have now been shown to possess six pairs (Fig. 47), as do Limulus and Scorpio.

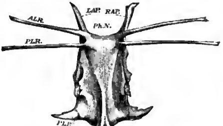


FIG. 1.—Entosternum, entosternite or plastron of *Limulus polyphemus*, Latr. Dorsal surface. LAP, left anterior process; RAP, right anterior process; PhN, pharyngeal notch; ALR, anterior lateral rod or tendon; PLR, posterior lateral rod or tendon; PLP, posterior lateral process. Natural size. (From Lankester, *Q. J. Mic. Sci.* N.S. vol. xxiv. 1884.)

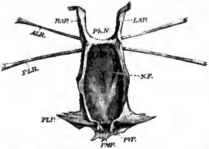


FIG. 2.—Ventral surface of the entosternum of *Limulus polyphemus*, Latr. Letters as in Fig. 1 with the addition of NF, neural fossa protecting the aggregated ganglia of the central nervous system; PVP, left posterior ventral process; PMP, posterior median process. Natural size. (From Lankester.)

The various comparisons previously made between the structure of Limulus and the Eurypterines on the one hand, and that of a typical Arachnid, such as Scorpio, on the other, had been vitiated by erroneous notions as to the origin of the nerves supplying the anterior appendages of Limulus (which were finally removed by Alphonse Milne-Edwards in his beautiful memoir (6) on the structure of that animal), and secondly by the erroneous identification of the double sternal plates of Limulus, called "chilaria," by Owen, with a pair of appendages (7). Once the identity of the chilaria with the pentagonal sternal plate of the scorpion is recognized — an identification first insisted on by Lankester — the whole series of segments and appendages in the two animals, Limulus and Scorpio, are seen to correspond most closely, segment for segment, with one another (see Figs. 7 and 8). The structure of the prosomatic appendages or legs is also seen to present many significant points of agreement (see figures), but a curious discrepancy existed in the six-jointed structure of the limb in Limulus, which differed from the seven-jointed limb of Scorpio by the defect of one joint. Mr R. I. Pocock of the British Museum has lately observed that in Limulus a marking exists on the fourth joint, which apparently indicates a previous division of this segment into two, and thus establishes the agreement of Limulus and Scorpio in this small feature of the number of segments in the legs (see Fig. 11).

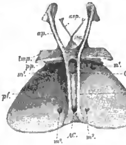


FIG. 3.—Entosternum of Scorpion (*Palamnæus indus*, De Geer); dorsal surface. *asp*, paired anterior process of the sub-neural arch; *sap*, sub-neural arch; *ap*, anterior lateral process (same as RAP and LAP in Fig. 1); *lmp*, lateral median process (same as ALR and PLR of Fig. 1); *pp*, posterior process (same as PLP in Fig. 1); *pf*, posterior flap or diaphragm of Newport; m¹ and m², perforations of the diaphragm for the passage of muscles; DR, the paired dorsal ridges; GC, gastric canal or foramen; AC, arterial canal or foramen. Magnified five times linear. (After Lankester, *loc. cit.*)

It is not desirable to occupy the limited space of this article by a full description of the limbs and segments of Limulus and Scorpio. The reader is referred to the complete series of figures here given, with their explanatory legends (Figs. 12, 13, 14, 15). Certain matters, however, require comment and explanation to render the comparison intelligible.[1] The tergites, or chitinized dorsal halves of the body rings, are fused to form a "prosomatic carapace," or carapace of the prosoma, in both Limulus and Scorpio (see Figs. 7 and 8). This region corresponds in both cases to six somites, as indicated by the presence of six pairs of limbs. On the surface of the carapace there are in both animals a pair of central eyes with simple lens and a pair of lateral eye-tracts, which in Limulus consist of closely-aggregated simple eyes, forming a "compound" eye, whilst in Scorpio they present

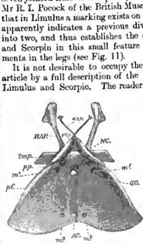


FIG. 4.—Ventral surface of the same entosternum as that drawn in Fig. 3. Letters as in Fig. 3 with the addition of NC, neural canal or foramen. (After Lankester, *loc. cit.*)

---

[1] The discussion of the segmentation or metamerism of the Arachnida in this article should be read after a perusal of the article ARTHROPODA by the same author.

several separate small eyes. The microscopic structure of the central and the lateral eyes has been shown by Lankester and Bourne (5) to differ; but the lateral eyes of Scorpio were shown by them to be similar in structure to the lateral eyes of Limulus and the central eyes of Scorpio to be identical in structure with the central eyes of Limulus (see below).

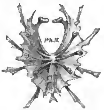


Fig. 5.—Entosternum of one of the mygalomorphous spiders; dorsal surface. Ph.N., pharyngeal notch. The three pairs of rod-like tendons correspond to the two similar pairs in Limulus, and the posterior median process with its repetition of triangular segments closely resembles the same process in Limulus. Magnified five times linear. (From Lankester, *loc. cit.*)

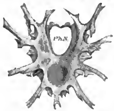


Fig. 6.—Ventral surface of the same entosternum as that drawn in Fig. 5. Ph.N., pharyngeal notch. Behind it on the body of the entosternum is seen the neural fossa, as in Fig. 2. (After Lankester, *loc. cit.*)

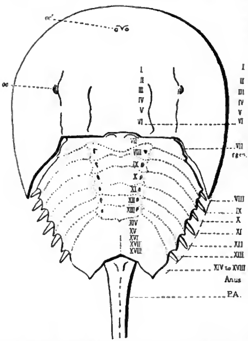


Fig. 7.—Diagram of the dorsal surface of *Limulus polyphemus*. *oc*, Lateral compound eyes; *oc'*, central monomeniscous eyes; PA, post-anal spine; I to VI, the six appendage-bearing somites of the prosoma; VII, usually considered to be the tergum of the genital somite, but suggested by Mr. Pocock to be that of the otherwise suppressed pregenital somite; VIII to XIII, the six somites of the mesosoma, each with a movable pleural spine and a pair of dorsal entopophysis or muscle-attaching ingrowths; XIV to XVIII, the confluent or unexpressed six somites of the metasoma. (From Lankester, *Q. J. Micr. Sci.* vol. xxi. 1881.) According to the system of numbering explained in the text, if VII is the tergum of the pregenital somite (as is probable) it should be labelled *Prg* without any number, and the somites VIII to XIII should be lettered 1 to 6, indicating that they are the six normal somites of the mesosoma; whilst XV to XVIII should be replaced by the numbers 7 to 12—an additional suppressed segment (making up the typical six) being reckoned to the metasomatic fusion.

Following the prosoma is a region consisting of six segments (Figs. 14 and 15), each carrying a pair of plate-like appendages in both Limulus and Scorpio. This region is called the mesosoma. The tergites of this region and those of the following region, the metasoma, are fused to form a second or posterior carapace in Limulus, whilst remaining free in Scorpio. The first pair of foliaceous appendages in each animal is the genital operculum; beneath it are found the openings of the genital ducts. The second pair of mesosomatic appendages in Scorpio are known as the "pectens." Each consists of an axis, bearing numerous blunt tooth-like processes arranged in a series. This is represented in Limulus by the first gill-bearing appendage. The leaves (some 150 in number) of the gill-book (see figure) correspond to the tooth-like processes of the pectens of Scorpio. The next four pairs of appendages (completing the mesosomatic series of six) consist, in both Scorpio and Limulus, of a base carrying each 130 to 150 blood-holding, leaf-like plates, lying on one another like the leaves of a book. Their minute structure is closely similar in the two cases; the leaf-like plates receive blood from the great sternal sinus, and serve as respiratory organs. The difference between the gill-books of Limulus and the lung-books of Scorpio depends on the fact that the latter are adapted to aerial respiration, while the former serve for aquatic respiration. The appendage carrying the gill-book stands out on the surface of the body in Limulus, and has other portions developed

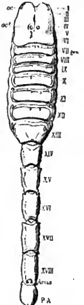


Fig. 8.—Diagram of the dorsal surface of a Scorpion to compare with Fig. 7. Letters and Roman numerals as in Fig. 7, excepting that VII is here certainly the tergum of the first somite of the mesosoma — the genital somite — and is not a survival of the embryonic pregenital somite. (From Lankester, *loc. cit.*) The anus (not seen) is on the sternal surface.

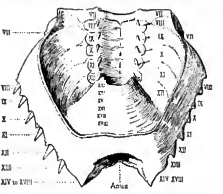


Fig. 9.—Ventral view of the posterior carapace or meso-meta-somatic (opisthosomatic) fusion of *Limulus polyphemus*. The soft integument and limbs of the mesosoma have been removed as well as all the viscera and muscles, so that the inner surface of the terga of these somites with their entopophyses are seen. The unsegmented dense chitinous sternal plate of the metasoma (XIII to XVIII) is not removed. Letters as in Fig. 7. (After Lankester, *loc. cit.*)

besides the gill-book and its base; it is fused with its fellow of the opposite side. On the other hand, in Scorpio, the gill-book-bearing appendage has sunk below the surface forming a recess or chamber for itself, which communicates with the exterior by an oval or circular "stigma" (Fig. 10, *stg*). That this in-sinking has taken place, and that the lung-books or in-sunken gill-books of Scorpio really represent appendages (that is to say, limbs or parapodia) is proved by their developmental history (see Figs. 17 and 18). They appear at first as outstanding processes on the surface of the body.

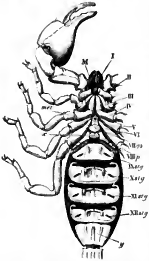


Fig. 10.—Ventral view of a Scorpion, *Palamnaeus indus*, De Geer, to show the arrangement of the coxæ of the limbs, the sternal elements, genital plate and pectens. M, mouth behind the oval median camerostome; I, the chelicerae; II, the chelæ; III to VI, the four pairs of walking legs; VII*go*, the genital somite or first somite of the mesosoma with the genital operculum (a fused pair of limbs); VIII*p*, the pectiniferous somite; IX*stg* to XII*stg*, the four pulmonary somites; *met*, the pentagonal metasternite of the prosoma behind all the coxæ; *x*, the sternum of the pectiniferous somite; *y*, the broad first somite of the metasoma.

The exact mode in which the in-sinking of superficial outstanding limbs, carrying gill-lamellæ, has historically taken place has been a matter of much speculation. It was to be hoped that the specimen of the Silurian scorpion (Palæophonus) from Scotland, showing the ventral surface of the mesosoma (Fig. 49), would throw light on this matter; but the specimen recently carefully studied by the writer and Mr Pocock reveals neither gill-bearing limbs nor stigmata. The probability appears to be against an actual introversion of the appendage and its lamellæ, as was at one time suggested by Lankester. It is probable that such an in-sinking as is shown in the accompanying diagram has taken place (Fig. 15); but we are yet in need of evidence as to the exact equivalence of margins, axis, &c., obtaining between the lung-book of Scorpio and the gill-book of Limulus. Zoologists are familiar with many instances (fishes, crustaceans) in which the protective walls of a water-breathing organ or gill-apparatus become converted into an air-breathing organ or lung, but there is no other case known of the conversion of gill processes themselves into air-breathing plates.

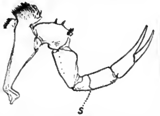


Fig. 11.—Third leg of *Limulus polyphemus*, showing the division of the fourth segment of the leg by a groove S into two, thus giving seven segments to the leg as in Scorpion. (From a drawing by Mr. Pocock.)

The identification of the lung-books of Scorpio with the gill-books of Limulus is practically settled by the existence of the pectens in Scorpio (Fig. 14, VIII.) on the second mesosomatic somite. There is no doubt that *these* are parapodial or limb appendages, carrying numerous imbricated secondary processes, and therefore comparable in essential structure to the leaf-bearing plates of the second mesosomatic somite of Limulus. They have remained unenclosed and projecting on the surface of the body, as once were the appendages of the four following somites. But they have lost their respiratory function. In non-aquatic life such an unprotected organ cannot subserve respiration. The "pectens" have become more firmly chitinized and probably somewhat altered in shape as compared with their condition in the aquatic ancestral scorpions. Their present function in scorpions is not ascertained. They are not specially sensitive under ordinary conditions, and may be touched or even pinched without causing any discomfort to the scorpion. It is probable that they acquire special

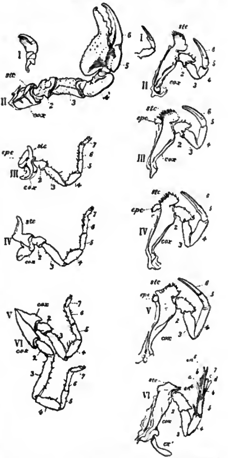


Fig. 12.—The prosomatic appendages of *Limulus polyphemus* (right) and Scorpio (left), *Palamnaeus indus* compared. The corresponding appendages are marked with the same Roman numeral. The Arabic numerals indicate the segments of the legs. *cox*, coxa or basal segment of the leg; *stc*, the sterno-coxal process or jaw-like up-growth of the coxa; *epc*, the articulated movable outgrowth of the coxa, called the epi-coxite (present only in III of the Scorpion and III, IV, and V of Limulus); *ex*¹, the exopodite of the sixth limb of Limulus; *a*, *b*, *c*, *d*, movable processes on the same leg (see for some suggestions on the morphology of this leg, Pocock in *Quart. Journ. Micr. Sci.* March 1901; see also Fig. 50 below and explanation.) (From Lankester, *loc. cit.*)

sensibility at the breeding season and serve as "guides" in copulation. The shape of the legs and the absence of paired terminal claws in the Silurian Palæophonus (see Figs. 48 and 49) as compared with living scorpions (see Fig. 10) show that the early scorpions were aquatic, and we may hope some day in better-preserved specimens than the two as yet discovered, to find the respiratory organs of those creatures in the condition of projecting appendages serving aquatic respiration somewhat as in Limulus, though not necessarily repeating the exact form of the broad plates of Limulus.

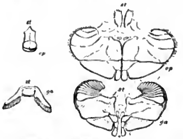


FIG. 13.—Diagrams of the meta-sternite *st*, with genital operculum *op*, and the first lamelligerous pair of appendages *ga*, with uniting sternal element *st* of Scorpio (left) and Limulus (right.) (From Lankester, *loc. cit.*)

It is important to note that the series of lamellæ of the lung-book and the gill-book correspond *exactly* in structure, the narrow, flat, blood-space in the lamellæ being interrupted by pillar-like junctions of the two surfaces in both cases (see Lankester (4)), and the free surfaces of the adjacent lamellæ being covered with a very delicate chitinous cuticle which is drawn out into delicate hairs and processes. The elongated axis which opens at the stigma in Scorpio and which can be cleared of soft, surrounding tissues and coagulated blood so as to present the appearance of a limb axis carrying the book-like leaves of the lung is not really, as it would seem to be at first sight, the limb axis. That is necessarily a blood-holding structure and is obliterated and fused with soft tissues of the sternal region so that the lamellæ cannot be detached and presented as standing out from it. The apparent axis or basal support of the scorpion's lung books shown in the figures, is a false or secondary axis and merely a part of the infolded surface which forms the air-chamber. The maceration of the soft parts of a scorpion preserved in weak spirit and the cleaning of the chitinized ingrown cuticle give rise to the false appearance of a limb axis carrying the lamellæ. The margins of the lamellæ of the scorpion's lung-book which are *lowermost* in the figures (Fig. 15) and appear to be free are really those which are attached to the blood-holding axis. The true free ends are those nearest the stigma.

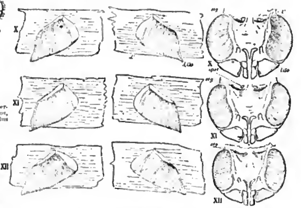


FIG. 15.—The remaining three pairs of mesosomatic appendages of Scorpio and Limulus. Letters as in Fig. 14. l130 indicates that there are 130 lamellæ in the Scorpion's lung-book, whilst l150 indicates that 150 similar lamellæ are counted in the gill of Limulus. (After Lankester, *loc. cit.*)

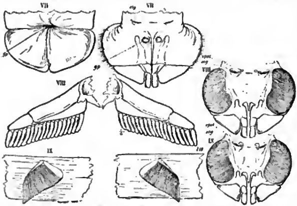


FIG. 14.—The first three pairs of mesosomatic appendages of Scorpio and Limulus compared. VII, the genital operculum; VIII, the pectens of Scorpio and the first branchial plate of Limulus; IX, the first pair of lung-books of Scorpio and the second branchial plate of Limulus; *gp*, genital pore; *epst*, epistigmatic sclerite; *stg*, stigma or orifice of the hollow tendons of the branchial plates of Limulus. (After Lankester, *loc. cit.*)

Passing on now from the mesosoma we come in Scorpio to the metasoma of six segments, the first of which is broad whilst the rest are cylindrical. The last is perforated by the anus and carries the post-anal spine or sting. The somites of the metasoma carry no parapodia. In Limulus the metasoma is practically suppressed. In the allied extinct Eurypterines it is well developed, and resembles that of Scorpio. In the embryo Limulus (Fig. 42) the six somites of the mesosoma are not fused to form a carapace at an early stage, and they are followed by three separately marked metasomatic somites; the other three somites of the metasoma have disappeared in Limulus, but are represented by the unsegmented pre-anal region. It is probable that we have in the metasoma of Limulus a case of the disappearance of once clearly demarcated somites. It would be possible to suppose, on the other hand, that new somites are only beginning to make their appearance here. The balance of various considerations is against the latter hypothesis. Following the metasoma in Limulus, we have as in Scorpio the post-anal spine—in this case not a sting, but a powerful and important organ of locomotion, serving to turn the animal over when it has fallen upon its back. The nature of the post-anal spine has been strangely misinterpreted by some writers. Owen (7) maintained that it represented a number of coalesced somites, regardless of its post-anal position and mode of development! The agreement of the grouping of the somites, of the form of the parapodia (appendages, limbs) in each region, of the position of the genital aperture and operculum, of the position and character of the eyes, and of the powerful post-anal spines not seen in other Arthropods, is very convincing as to the affinity of Limulus and Scorpio. Perhaps the most important general agreement of Scorpio compared with Limulus and the Eurypterines is the division of the body into the three regions (or tagmata) — prosoma, mesosoma, and metasoma — each consisting of six segments, the prosoma having leg-like appendages, the mesosoma having foliaceous appendages, and the metasoma being destitute of appendages.

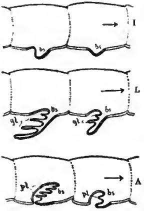


FIG. 16.—Diagram to show the way in which an outgrowing gill-process bearing blood-holding lamellæ may give rise, if the sternal body wall sinks inwards, to a lung-chamber with air-holding lamellæ. I is the embryonic condition; *bs*, blood sinus; L is the condition of out-growth with *gl*, gill lamellæ; A is the condition of in-sinking of the sternal surface and consequent enclosure of the lamelligerous surface of the appendage in a chamber with narrow orifice—the pulmonary air-holding chamber; *pl*, pulmonary lamellæ; *bs*, blood sinus. (After Kingsley.)

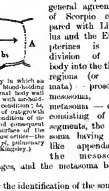


FIG. 17.—Embryo of Scorpion, ventral view showing somites and appendages. *syc*, frontal groove; *sa*, rudiment of lateral eyes; *obl*, camerostome (upper lip); *so*, sense-organ of Patten. PrGabp1, rudiment of the appendage of the prægenital somite which disappears; *abp*2, rudiment of the right half of the genital operculum; *abp*3, rudiment of the right pecten; *abp*4 to *abp*7, rudiments of the four appendages which carry the pulmonary lamellæ; I to VI, rudiments of the six limbs of the prosoma; VIIPrG, the evanescent prægenital somite; VIII, the first mesosomatic somite or genital somite; IX, the second mesosomatic somite or pectiniferous somite; X to XIII, the four pulmoniferous somites; XIV, the first metasomatic somite. (After Brauer, *Zeitsch. wiss. Zool.* vol. lix. 1895.)

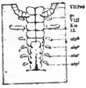


FIG. 18.—Portion of a similar embryo at a later stage of growth. The prægenital somite, VIIPrG, is still present, but has lost its rudimentary appendages; *go*, the genital operculum, left half; Km, the left pecten; *abp*4 to *abp*7, the rudimentary appendages of the lung-sacs. (After Brauer, *loc. cit.*)

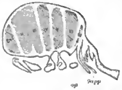


FIG. 19.—Section through an early embryo of *Limulus longispina*, showing seven transverse divisions in the region of the unsegmented anterior carapace. The seventh, VII, is anterior to the genital operculum, *op*, and is the cavity of the prægenital somite which is more or less completely suppressed in subsequent development, possibly indicated by the area marked VII. in Fig. 7 and by the great entopophyses of the prosomatic carapace. (After Kishinouye, *Journ. Sci. Coll. Japan*, vol. v. 1892.)

In 1893, some years after the identification of the somites of Limulus with those of Scorpio, thus indicated, had been published, zoologists were startled by the discovery by a Japanese zoologist, Mr Kishinouye (**8**) of a seventh prosomatic somite in the embryo of Limulus longispina. This was seen in longitudinal sections, as shown in Fig. 19. The simple identification of somite with somite in Limulus and Scorpio seemed to be threatened by this discovery. But in 1896 Dr August Brauer of Marburg (**9**) discovered in the embryo of Scorpio a seventh prosomatic somite (see VII.PrG, Figs. 17 and 18), or, if we please so to term it, a *prægenital* somite, hitherto unrecognized. In the case of Scorpio this segment is indicated in the embryo by the presence of a pair of rudimentary appendages, carried by a well-marked somite. As in Limulus, so in Scorpio, this unexpected somite and its appendages disappear in the course of development. In fact, more or less complete "excalation" of the somite takes place. Owing to its position it is convenient to term the somite which is excalated in Limulus and Scorpio "the prægenital somite." It appears not improbable that the sternal plates wedged in between the last pair of legs in both Scorpio and Limulus, viz., the pentagonal sternite of Scorpio (Fig. 10) and the chilaria of Limulus (see Figs. 13 and 20), may in part represent in the adult the sternum of the excalated prægenital somite. This has not been demonstrated by an actual following out of the development, but the position of these pieces and the fact that they are (in Limulus) supplied by an independent segmental nerve, favours the view that they may comprise the sternal area of the vanished prægenital somite. This interpretation, however, of the "metasternites" of Limulus and Scorpio is opposed by the coexistence in Thelyphonus (Figs. 55, 57, and 58) of a similar metasternite with a complete prægenital somite. Hansen (**10**) has recognized that the "prægenital somite" persists in a rudimentary condition, forming a "waist" to the series of somites in the Pedipalpi and Araneæ. The present writer is of opinion that it will be found most convenient to treat this evanescent somite as something special, and not to attempt to reckon it to either the prosoma or the mesosoma. These will then remain as typically composed each of six appendage-bearing somites—the prosoma comprising in addition the ocular prosthomere.[1] When the prægenital somite or traces of it are present it should not be called "the seventh prosomatic" or the "first mesosomatic," but simply the "prægenital somite." The first segment of the mesosoma of Scorpio and Limulus thus remains the first segment, and can be identified as such throughout the Eu-arachnida, carrying as it always does the genital apertures. But it is necessary to remember, in the light of recent discoveries, that the sixth prosomatic pair of appendages is carried on the seventh somite of the whole series, there being two prosthomeres or somites in front of the mouth, the first carrying the eyes, the second the cheliceræ; also that the first mesosomatic or genital somite is not the seventh or even the eighth of the whole series of somites which have been historically present, but is the ninth, owing to the presence or to the excalation of a prægenital somite. It seems that confusion and trouble will be best avoided by abstaining from the introduction of the non-evident somites, the ocular and the prægenital, into the numerical nomenclature of the component somites of the three great body regions. We shall, therefore, ignoring the ocular somite, speak of the first, second, third, fourth, fifth, and sixth leg-bearing somites of the prosoma and indicate the appendages by the Roman numerals, I., II., III., IV., V., VI., and whilst ignoring the prægenital somite we shall speak of the first, second, third, &c. somite of the mesosoma or opisthosoma (united mesosoma and metasoma) and indicate them by the Arabic numerals.

---

[1] See the article ARTHROPODA for the use of the term "prosthomere."

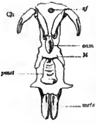


FIG. 20.—View of the ventral surface of the mid-line of the prosomatic region of *Limulus polyphemus*. The coxæ of the five pairs of limbs following the chelicerae were arranged in a series on each side between the mouth, M, and the metasternites, *mets*. *sf*, The subfrontal median sclerite; Ch, the chelicerae; *cam*, the camerostome or upper lip; M, the mouth; *pmst*, the promesosternal sclerite or chitinous plate, unpaired; *mets*, the right and left metasternites (corresponding to the similarly placed pentagonal sternite of Scorpio. Natural size. (After Lankester.)

There are a number of other important points of structure besides those referring to the somites and appendages in which Limulus agrees with Scorpio or other Arachnida and differs from other Arthropoda. The chief of these are as follows:—

1. *The Composition of the Head* (that is to say, of the anterior part of the prosoma) *with especial Reference to the Region in Front of the Mouth.*—It appears (see ARTHROPODA) that there is embryological evidence of the existence of two somites in Arachnida which were originally post-oral, but have become præ-oral by adaptational shifting of the oral aperture. These forwardly-slipped somites are called "prosthomeres." The first of these has, in Arachnids as in other Arthropods, its pair of appendages represented by the eyes. The second has for its pair of appendages the small pair of limbs which in all living Arachnids is either chelate or retrovert (as in spiders), and is known as the chelicerae. It is possible, as maintained by some writers (Patten and others), that the lobes of the cerebral nervous mass in Arachnids indicate a larger number of prosthomeres as having fused in this region, but there is no *embryological* evidence at present which justifies us in assuming the existence in Arachnids of more than two prosthomeres. The position of the chelicerae of Limulus and of the ganglionic nerve-masses from which they receive their nerve-supply, is closely similar to that of the same structures in Scorpio. The cerebral mass is in Limulus more easily separated by dissection as a median lobe distinct from the laterally-placed ganglia of the cheliceral somite than is the case in Scorpio, but the relations are practically the same in the two forms. Formerly it was supposed that in Limulus both the chelicerae and the next following pair of appendages were prosthomerous, as in Crustacea, but the dissections of Alphonse Milne-Edwards (**6**) demonstrated the true limitations of the cerebrum, whilst embryological researches have done as much for Scorpio. Limulus thus agrees with Scorpio and differs from the Crustacea, in which there are three prosthomeres—one ocular and two carrying palpiform appendages. It is true that in the lower Crustacea (Apus, &c.) we have evidence of the gradual movement forward of the nerve-ganglia belonging to these palpiform appendages. But although in such lower Crustacea the nerve-ganglia of the third prosthomere have not fused with the anterior nerve-mass, there is no question as to the præ-oral position of two appendage-bearing somites in addition to the ocular prosthomere. The Crustacea have, in fact, three prosthomeres in the head and the Arachnida only two, and Limulus agrees with the Arachnida in this respect and differs from the Crustacea. The central nervous systems of Limulus and of Scorpio present closer agreement in structure than can be found when a Crustacean is compared with either. The wide divarication of the lateral cords in the prosoma and their connexion by transverse commissures, together with the "attraction" of ganglia to the prosomatic ganglion group which properly belong to hinder segments, are very nearly identical in the two animals. The form and disposition of the ganglion cells are also peculiar and closely similar in the two. (See Patten (**42**) for important observations on the neuromeres, &c., of Limulus and Scorpio.)

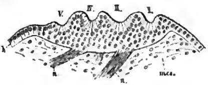


FIG. 21.—Development of the lateral eyes of a Scorpion. *h*, epidermic cell-layer; *mes*, mesoblastic connective tissue; *n*, nerves; II, III, IV, V, depressions of the epidermis in each of which a cuticular lens will be formed. (From Korschelt and Heider, after Laurie.)

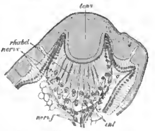


FIG. 22.—Section through the lateral eye of *Euscorpius italicus*. *lens*, Cuticular lens; *nerv.r*, retinal cells (nerve-end cells); *rhabd*, rhabdomes; *nerv.f*, nerve fibres of the optic nerve; *int*, intermediate cells (lying between the bases of the retinal cells). (After Lankester and Bourne from Parker and Haswell's *Text-book of Zoology*, Macmillan and Co.)

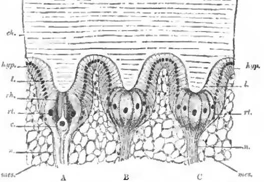


FIG. 23.—Section through a portion of the lateral eye of Limulus, showing three ommatidia—A, B, and C. *hyp*, The epidermic cell-layer (so-called hypodermis), the cells of which increase in volume below each lens, *l*, and become nerve-end cells or retinula-cells, *rt*; in A the letters *rh* point to a rhabdomere secreted by the cell *rt*; *c*, the peculiar central spherical cell; *n*, nerve fibres; *mes*, mesoblastic skeletal tissue; *ch*, chitinous cuticle. (From Korschelt and Heider after Watase.)

2. *The Minute Structure of the Central Eyes and of the Lateral Eyes.*—Limulus agrees with Scorpio not only in having a pair of central eyes and also lateral eyes, but in the microscopic structure of those organs which differs in

the central and lateral eyes respectively. The central eyes are "simple eyes," that is to say, have a single lens, and are hence called "monomeniscous." The lateral eyes are in Limulus "compound eyes," that is to say, consist of many lenses placed close together; beneath each lens is a complex of protoplasmic cells, in which the optic nerve terminates. Each such unit is termed an "ommatidium." The lateral eyes of Scorpio consist of groups of separate small lenses each with its ommatidium, but they do not form a continuous compound eye as in Limulus. The ommatidium (soft structure beneath the lens-unit of a compound eye) is very simple in both Scorpio and Limulus. It consists of a single layer of cells, continuous with those which secrete the general chitinous covering of the prosoma. The cells of the ommatidium are a good deal larger than the neighbouring common cells of the epidermis. They secrete the knob-like lens (Fig. 22). But they also receive the nerve fibres of the optic nerve. They are at the same time both optic nerve-end cells, that is to say, retina cells and corneagen cells or secretors of the chitinous lens-like cornea. In Limulus (Fig. 23) each ommatidium has a peculiar ganglion cell developed in a central position, whilst the ommatidium of the lateral eyelets of Scorpio shows small intermediate cells between the larger nerve-end cells. The structure of the lateral eye of Limulus was first described by Grenacher, and further and more accurately by Lankester and Bourne (**5**) and by Watase; that of Scorpio by Lankester and Bourne, who showed that the statements of von Graber were erroneous, and that the lateral eyes of Scorpio have a single cell-layered or "monostichous" ommatidium like that of Limulus. Watase has shown, in a very convincing way, how by deepening the pit-like set of cells beneath a simple lens the more complex ommatidia of the compound eyes of Crustacea and Hexapoda may be derived from such a condition as that presented in the lateral eyes of Limulus and Scorpio. (For details the reader is referred to Watase (**11**) and to Lankester and Bourne (**5**).) The structure of the central eyes of Scorpio and Spiders and also of Limulus differs essentially from that of the lateral eyes in having two layers of cells (hence called diplostichous) beneath the lens, separated from one another by a membrane (Figs. 24 and 25). The upper layer is the corneagen and secretes the lens, the lower is the retinal layer. The mass of soft cell-structures beneath a large lens of a central eye is called an "ommateum." It shows in Scorpio and Limulus a tendency to segregate into minor groups or "ommatidia." It is found that in embryological growth the retinal layer of the central eyes forms as a separate pouch, which is pushed in laterally beneath the corneagen layer from the epidermic cell layer. Hence it is in origin double, and consists of a true retinal layer and a post-retinal layer (Fig. 24, B), though these are not separated by a membrane. Accordingly the diplostichous ommatœum or soft tissue of the Arachnid's central eye should strictly be called "triplostichous," since the deep layer is itself doubled or folded. The retinal cells of both the lateral and central eyes of Limulus and Scorpio produce cuticular structures on their sides; each such piece is a rhabdomere and a number (five or ten) uniting form a rhabdom (Fig. 26). In the specialized ommatidia of the compound eyes of Crustacea and Hexapods the rhabdom is an important structure.[1] It is a very significant fact that the lateral and central eyes of Limulus and Scorpio not only agree each with each in regard to their monostichous and diplostichous structure but also in the formation in both classes of eyes of rhabdomeres and rhabdoms in which the component pieces are five or a multiple of five (Fig. 26). Whilst each unit of the lateral eye of Limulus has a rhabdom of ten[2] pieces

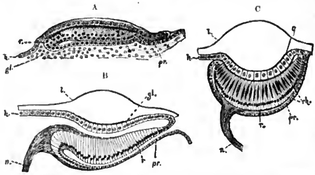


Fig. 24.—Diagrams of the development and adult structure of one of the paired central eyes of a Scorpion. A, early condition before the lens is deposited, showing the folding of the epidermic cell-layer into three; B, diagram showing the nature of this infolding; C, section through the fully formed eye; *h*, epidermic cell-layer; *r*, the retinal portion of the same which, owing to the infolding, lies between *gl*, the corneagen or lens-forming portion, and *pr*, the post-retinal or capsular portion or fold; *l*, cuticular lens; *g*, line separating lens from the lens-forming or corneagen cells of the epidermis; *n*, nerve fibres; *rh*, rhabdomeres. (From Korschelt and Heider.) How the inversion of the nerve-end-cells and their connexion with the nerve-fibres is to be reconciled with the condition found in the adult, or with that of the monostichous eye, has not hitherto been explained.

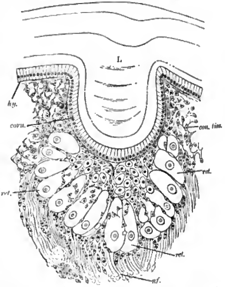


Fig. 25.—Section through one of the central eyes of a young Limulus. L, cuticular or corneous lens; *hy*, epidermic cell-layer; *corn.*, its corneagen portion immediately underlying the lens; *ret.*, retinula cells; *nf*, nerve fibres; *con. tis.*, connective tissue (mesoblastic skeletal tissue). (After Lankester and Bourne, *Q. J. Mic. Sci.* 1883.)

---

[1] See Fig. 11 in the article ARTHROPODA.

[2] Though ten is the prevailing number of retinula cells and rhabdomeres in the lateral eye of Limulus, Watase states that they may be as few as nine and as many as eighteen.

forming a star-like chitinous centre in section, each lateral eye of Scorpio has several rhabdoms of five or less rhabdomeres, indicating that the Limulus lateral eye-unit is more specialized than the detached lateral eyelet of Scorpio, so as to present a coincidence of one lens with one rhabdom. Numerous rhabdomeres (grouped as rhabdoms in Limulus) are found in the retinal layer of the central eyes also.

Whilst Limulus agrees thus closely with Scorpio in regard to the eyes, it is to be noted that no Crustacean has structures corresponding to the peculiar diplostichous central eyes, though these occur again (with differences in detail) in Hexapoda. Possibly, however, an investigation of the development of the median eyes of some Crustacea (Apus, Palæmon) may prove them to be diplostichous in origin.

3. *The so-called "Coxal Glands."*—In 1882 (*Proc. Roy. Soc.* No. 221) Lankester described under the name "coxal glands" a pair of brilliantly white oviform bodies lying in the Scorpion's prosoma immediately above the coxæ of the fifth and sixth pairs of legs (Fig. 27). These bodies had been erroneously supposed by Newport (**12**) and other observers to be glandular outgrowths of the alimentary canal. They are really excretory glands, and communicate with the exterior by a very minute aperture on the posterior face of the coxa of the fifth limb on each side. When examined with the microscope, by means of the usual section method, they are seen to consist of a labyrinthine tube lined with peculiar cells, each cell having a deep vertically striated border on the surface farthest from the lumen, as is seen in the cells of some renal organs. The coils and branches of the tube are packed by connective tissue and blood spaces. A similar pair of coxal glands, lobate instead of ovoid in shape, was described by Lankester in Mygale, and it was also shown by him that the structures in Limulus called "brick-red glands" by Packard have the same structure and position as the coxal glands of Scorpio and Mygale. In Limulus these organs consist each of four horizontal lobes lying on the coxal margin of the second, third, fourth, and fifth prosomatic limbs, the four lobes being connected to one another by a transverse piece or stem (Fig. 28). Microscopically their structure is the same in essentials as that of the coxal glands of Scorpio (**13**). Coxal glands have since been recognized and described in other Arachnida. It has lately (1900) been shown that the coxal gland of Limulus is provided with a very delicate thin-walled coiled duct which opens, even in the adult condition, by a minute pore on the coxa of the fifth leg (Patten and Hazen, **13A**). Previously to this, Lankester's pupil Gulland had shown (1885) that in the embryo the coxal gland is a comparatively simple tube, which opens to the exterior in this position and by its other extremity into a cœlomic space. Similar observations were made by Laurie (**17**) in Lankester's laboratory (1890) with regard to the early condition of the coxal gland of Scorpio, and by Bertkau (**41**) as to that of the spider Atypus. H. M. Bernard (**13B**) showed that the opening remains in the adult Scorpion. In all the embryonic or permanent opening is on the coxa of the fifth pair of prosomatic limbs. Thus an organ newly discovered in Scorpio was found to have its counterpart in Limulus.

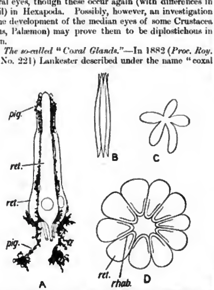


FIG. 26.—A, diagram of a retinula of the central eye of a Scorpion consisting of five retina-cells (*ret.*), with adherent branched pigment cells (*pig.*); B, rhabdom of the same, consisting of five confluent rhabdomeres; C, transverse section of the rhabdom of a retinula of the Scorpion's central eye, showing its five constituent rhabdomeres as rays of a star; D, transverse section of a retinula of the lateral eye of Limulus, showing ten retinula cells, *ret.*, each bearing a rhabdomere, *rhab.* (After Lankester.)

The name "coxal gland" needs to be carefully distinguished from "crural gland," with which it is apt to be confused. The crural glands, which occur in many terrestrial Arthropods, are epidermal in origin and totally distinct from the coxal glands. The coxal glands of the Arachnida are structures of the same nature as the green-glands of the higher Crustacea and the so-called "shell glands" of the Entomostraca. The latter open at the base of the fifth pair of limbs of the Crustacean, just as the coxal glands open on the coxal joint of the fifth pair of limbs of the Arachnid. Both belong to the category of "cœlomoducts," namely, tubular or funnel-like portions of the cœlom opening to the exterior in pairs in each somite (potentially), and usually persisting in only a few somites as either "urocœls" (renal organs) or "gonocœls" (genital tubes). In Peripatus they occur in every somite of the body. They have till recently been very generally identified with the nephridia of Chætopod worms, but there is good reason for considering the true nephridia (typified by the nephridia of the Earthworm) as a distinct class of organs (see Lankester in vol. ii. chap. iii. of *A Treatise on Zoology*, 1900). The genital ducts of Arthropoda are like the green glands, shell glands, and coxal glands, to be regarded as cœlomoducts (gonocœls) The coxal glands do not establish any special connexion between Limulus and Scorpio, since they also occur in the same somite in the lower Crustacea, but it is to be noted that the coxal glands of Limulus are in minute structure and probably in function more like those of Arachnids than those of Crustacea.

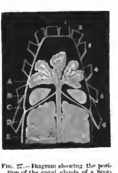


FIG. 27.—Diagram showing the position of the coxal glands of a Scorpion, *Buthus australis*, Lin., in relation to the legs, diaphragm (entosternal flap), and the gastric cæca. 1 to 6, The bases of the six prosomatic limbs; A, prosomatic gastric gland (sometimes called salivary); B, coxal gland; C, diaphragm of Newport = fibrous flap of the entosternum; D, mesosomatic gastric cæca (so-called liver); E, alimentary canal. (From Lankester, *Q. J. Mic. Sci.* vol. xxiv. N.S. p. 152.)

4. *The Entosternites and their Minute Structure.*—Straus-Durkheim (**1**) was the first to insist on the affinity between Limulus and the Arachnids, indicated by the presence of a free suspended entosternum or plastron or entosternite in both. We have figured here (Figs. 1 to 6) the entosternites of Limulus, Scorpio, and Mygale. Lankester some years ago made a special study of the histology

(3) of these entosternites for the purpose of comparison, and also ascertained the relations of the very numerous muscles which are inserted into them (4). The entosternites are cartilaginous in texture, but they have neither the chemical character nor the microscopic structure of the hyaline cartilage of Vertebrates. They yield chitin in place of chondrin or gelatin—as does also the cartilage of the Cephalopod's endoskeleton. In microscopic structure they all present the closest agreement with one another. We find a firm, homogeneous or sparsely fibrillated matrix in which are embedded nucleated cells (corpuscles of protoplasm) arranged in rows of three, six, or eight, parallel with the adjacent lines of fibrillation.

A minute entosternite having the above-described structure is found in the Crustacean Apus between the bases of the mandibles, and also in the Decapoda in a similar position, but in no Crustacean does it attain to any size or importance. On the other hand, the entosternite of the Arachnida is a very large and important feature in the structure of the prosoma, and must play an important part in the economy of these organisms. In Limulus (Figs. 1 and 2) it has as many as twenty-five pairs of muscles attached to it, coming to it from the bases of the surrounding limbs and from the dorsal carapace and from the pharynx. It consists of an oblong plate two inches in length and one in breadth, with a pair of tendinous outgrowths standing out from it at right angles on each side. It "floats" between the prosomatic nerve centres and the alimentary canal. In each somite of the mesosoma is a small, free entosternite having a similar position, but below or ventrad of the nerve cords, and having a smaller number of muscles attached to it. The entosternite was probably in origin part of the fibrous connective tissue lying close to the integument of the sternal surface—giving attachment to muscles corresponding more or less to those at present attached to it. It became isolated and detached, why or with what advantage to the organism it is difficult to say, and at that period of Arachnidan development the great ventral nerve cords occupied a more lateral position than they do at present. We know that such a lateral position of the nerve cords preceded the median position in both Arthropoda and Chætopoda. Subsequently to the floating off of the entosternite the approximation of the nerve cords took place in the prosoma, and thus they were able to take up a position below the entosternite. In the mesosoma the approximation had occurred before the entosternites were formed.

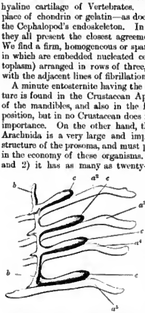


FIG. 28.—The right coxal gland of *Limulus polyphemus*, Latr. a^2 to a^5, Posterior borders of the chitinous bases of the coxæ of the second, third, fourth, and fifth prosomatic limbs; *b*, longitudinal lobe or stolon of the coxal gland; *c*, its four transverse lobes or outgrowths corresponding to the four coxæ. (From Lankester, *loc. cit.*, after Packard.)

In the Scorpion (Figs. 3 and 4) the entosternite has tough membrane-like outgrowths which connect it with the body-wall, both dorsally and ventrally forming an oblique diaphragm, cutting off the cavity of the prosoma from that of the mesosoma. It was described by Newport as "the diaphragm." Only the central and horizontal parts of this structure correspond precisely to the entosternite of Limulus: the right and left anterior processes (marked *ap* in Figs. 3 and 4, and RAP, LAP, in Figs. 1 and 2) correspond in the two animals, and the median lateral process *lmp* of the Scorpion represents the tendinous outgrowths ALR, PLR of Limulus. The Scorpion's entosternite gives rise to outgrowths, besides the great posterior flaps, *pf*, which form the diaphragm, unrepresented in Limulus. These are a ventral arch forming a neural canal through which the great nerve cords pass (Figs. 3 and 4, *snp*), and further a dorsal gastric canal and arterial canal which transmit the alimentary tract and the dorsal artery respectively (Figs. 3 and 4, GC, DR).

In Limulus small entosternites are found in each somite of the appendage-bearing mesosoma, and we find in Scorpio, in the only somite of the mesosoma which has a well-developed pair of appendages, that of the pectens, a small entosternite with ten pairs of muscles inserted into it. The supra-pectinal entosternite lies ventrad of the nerve cords.

In Mygale (Figs. 5 and 6) the form of the entosternite is more like that of Limulus than is that of Scorpio. The anterior notch Ph.N. is similar to that in Limulus, and the three pairs of upstanding tendons on the dorsal surface correspond to the two similar pairs in Limulus, whilst the imbricate triangular pieces of the posterior median region resemble the similarly-placed structures of Limulue in a striking manner.

It must be confessed that we are singularly ignorant as to the functional significance of these remarkable organs—the entosternites. Their movement in an upward or downward direction in Limulus and Mygale must exert a pumping action on the blood contained in the dorsal arteries and the ventral veins respectively. In Scorpio the completion of the horizontal plate by oblique flaps, so as to form an actual diaphragm shutting off the cavity of the prosoma from the rest of the body, possibly gives to the organs contained in the anterior chamber a physiological advantage in respect of the supply of arterial blood and its separation from the venous blood of the mesosoma. Possibly the movement of the diaphragm may determine the passage of air into or out of the lung-sacs. Muscular fibres connected with the suctorial pharynx are in Limulus inserted into the entosternite, and the activity of the two organs may be correlated.

5. *The Blood and the Blood-vascular System.*—The blood fluids of Limulus and Scorpio are very similar. Not only are the blood corpuscles of Limulus more like in form and granulation to those of Scorpio than to those of any Crustacean, but the fluid is in both animals strongly impregnated with the blue-coloured respiratory proteid Hæmocyanin. This body occurs also in the blood of Crustacea and of Molluscs, but its abundance in both Limulus and Scorpio is very marked, and gives to the freshly-shed blood a strong indigo-blue tint.

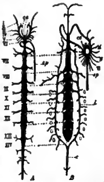


FIG. 29.—Diagram of the arterial system of A, Scorpio, and B, Limulus. The Roman numerals indicate the body somites and the two figures are adjusted for comparison. *ce*, Cerebral arteries; *sp*, supra-spinal or medullary artery; *c*, caudal artery; *l*, lateral anastomotic artery of Limulus. The figure B also shows the peculiar neural investiture formed by the cerebral arteries in Limulus and the derivation from this of the arteries to the limbs, III, IV, VI, whereas in Scorpio the latter have a separate origin from the anterior aorta. (From Lankester, "Limulus an Arachnid.")

The great dorsal contractile vessel or "heart" of Limulus is closely similar to that of Scorpio; its ostia or incurrent orifices are placed in the same somites as those of Scorpio, but there is one additional posterior pair. The origin of the paired arteries from the heart differs in Limulus from the arrangement obtaining in Scorpio, in that a pair of lateral commissural arteries exist in Limulus (as described by Alphonse Milne-Edwards (6)) leading to a suppression of the more primitive direct connexion of the four pairs of posterior lateral arteries, and of the great median posterior arteries with the heart itself (Fig. 29). The arterial system is very completely developed in both Limulus and Scorpio, branching repeatedly until minute arterioles are formed, not to be distinguished from true capillaries; these open into irregular swollen vessels which are the veins or venous sinuses. A very remarkable feature in Limulus, first described by Owen, is the close accompaniment of the prosomatic nerve centres and nerves by arteries, so close indeed that the great ganglion mass and its outrunning nerves are actually sunk in or invested by arteries. The connexion is not so intimate in Scorpio, but is nevertheless a very close one, closer than we find in any other Arthropods in which the arterial system is well developed, *e.g.*, the Myriapoda and some of the arthrostracous Crustacea.

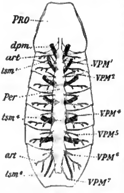


FIG. 30.—View from below of a Scorpion (*S. occitanus*) opened and dissected so as to show the pericardium with its muscles, the lateral arteries, and the tergo-sternal muscles. PRO, prosoma; *dpm*, dorso-plastral muscle; *art*, lateral artery; *tsm*^{1}, tergo-sternal muscle (labelled *dv* in Fig. 31) of the second (pectiniferous) mesosomatic somite: this is the most anterior pair of the series of six, none are present in the genital somite; *tsm*^{4}, tergo-sternal muscle of the fifth mesosomatic somite; *tsm*^{6}, tergo-sternal muscle of the enlarged first metasomatic somite; *Per*, pericardium; VPM^1 to VPM^7, the series of seven pairs of veno-pericardiac muscles (labelled *pv* in Fig. 31). There is some reason to admit the existence of another more anterior pair of these muscles in Scorpio; this would make the number exactly correspond with the number in Limulus. (After Lankester, *Trans. Zool. Soc.* vol. xi. 1883.)

It seems that there is a primitive tendency in the Arthropoda for the arteries to accompany the nerve cords, and a "supra-spinal" artery—that is to say, an artery in close relation to the ventral nerve cords—has been described in several cases. On the other hand, in many Arthropods, especially those which possess tracheæ, the arteries do not have a long course, but soon open into wide blood sinuses. Scorpio certainly comes nearer to Limulus in the high development of its arterial system, and the intimate relation of the anterior aorta and its branches to the nerve centres and great nerves, than does any other Arthropod.

An arrangement of great functional importance in regard to the venous system must now be described, which was shown in 1883 by Lankester to be common to Limulus and Scorpio. This arrangement has not hitherto been detected in any other class than the Arachnida, and if it should ultimately prove to be peculiar to that group, would have considerable weight as a proof of the close genetic affinity of Limulus and Scorpio.

The great pericardial sinus is strongly developed in both animals. Its walls are fibrous and complete, and it holds a considerable volume of blood when the heart itself is contracted. Opening in pairs in each somite, right and left into the pericardial sinus are large veins, which bring the blood respectively from the gill-books and the lung-books to that chamber, whence it passes by the ostia into the heart. The blood is brought to the respiratory organs in both cases by a great venous-collecting sinus having a ventral median position. In both animals *the wall of the pericardial sinus is connected by vertical muscular bands to the wall of the ventral venous sinus* (its lateral expansions around the lung-books in Scorpio) in each somite through which the pericardium passes. There are seven pairs of these *veno-pericardiac vertical muscles* in Scorpio, and eight in Limulus (see Figs. 30, 31, 32). It is obvious that the contraction of these muscles must cause a depression of the floor of the pericardium and a rising of the roof of the ventral blood sinus, and a consequent increase of volume and flow of blood to each. Whether the pericardium and the ventral sinus are made to expand simultaneously or all the movement is made by one only of the surfaces concerned, must depend on conditions of tension. In any case it is clear that we have in these muscles an apparatus for causing the blood to flow differentially in increased volume into either the pericardium, through the veins leading from the respiratory organs, or from the body generally into the great sinuses which bring the blood to the respiratory organs. These muscles act so as to pump the blood through the respiratory organs.

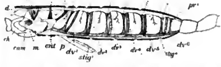


FIG. 31.—Diagram of a lateral view of a longitudinal section of a Scorpion. *d*, chelicera; *ch*, chela; *cam*, camerostome; *m*, mouth; *ent*, entosternum; *p*, pecten; *stig*^{1}, first pulmonary aperture; *stig*^{4}, fourth pulmonary aperture; *dam*, muscle from carapace to a preoral entosclerite; *ed*, muscle from carapace to entosternum; *md*, muscle from tergite of genital somite to entosternum (same as *dpm* in Fig. 30); *dv*^{1} to *dv*^{6}, dorso-ventral muscles (same as the series labelled *tsm* in Fig. 30); *pv*^{1} to *pv*^{7}, the seven veno-pericardiac muscles of the right side (labelled VPM in Fig. 30). (After Beck, *Trans. Zool. Soc.* vol. xi. 1883.)

It is not surprising that with so highly developed an arterial system Limulus and Scorpio should have a highly developed mechanism for determining the flow of blood to the respiratory organs. That this is, so to speak, a need of animals with localized respiratory organs is seen by the existence of provisions serving a similar purpose in other animals, *e.g.*, the branchial hearts of the Cephalopoda.

The veno-pericardiac muscles of Scorpio were seen and figured by Newport but not described by him. Those of Limulus were described and figured by Alphonse Milne-Edwards, but he called them merely "transparent ligaments," and did not discover their muscular structure. They are figured and their importance for the first time

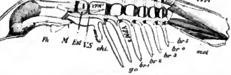


FIG. 32.—Diagram of a lateral view of a longitudinal section of Limulus. *Suc*, suctorial pharynx; *al*, alimentary canal; *Ph*, pharynx; *M*, mouth; *Est*, entosternum; VS, ventral venous sinus; *chi*, chilaria; *go*, genital operculum; *br*^{1} to *br*^{5}, branchial appendages; *met*, unsegmented metasoma; *Entap*^{4}, fourth dorsal entapophysis of left side; *tsm*, tergo-sternal muscles, six pairs as in Scorpio (labelled *dv* in Fig 31); VPM^1 to VPM^8, the eight pairs of veno-pericardiac muscles (labelled *pv* in Fig. 31). VPM^1 is probably represented in Scorpio, though not marked in Figs. 30 and 31. (After Benham, *Trans. Zool. Soc.* vol. xi. 1883.)

recognized in the memoir on the muscular and skeletal systems of Limulus and Scorpio by Lankester, Beck, and Bourne (4).

6. *Alimentary Canal and Gastric Glands.*—The alimentary canal in Scorpio, as in Limulus, is provided with a powerful suctorial pharynx, in the working of which extrinsic muscles take a part. The mouth is relatively smaller in Scorpio than in Limulus—in fact is minute, as it is in all the terrestrial Arachnida which suck the juices of either animals or plants. In both, the alimentary canal takes a straight course from the pharynx (which bends under it downwards and backwards towards the mouth in Limulus) to the anus, and is a simple, narrow, cylindrical tube (Fig. 33). The only point in which the gut of Limulus resembles that of Scorpio rather than that of any of the Crustacea, is in possessing more than a single pair of ducts or lateral outgrowths connected with ramified gastric glands or gastric cæca. Limulus has two pairs of these, Scorpio as many as six pairs. The Crustacea never have more than one pair. The minute microscopic structure of the gastric glands in the two animals is practically identical. The functions of these gastric diverticula have never been carefully investigated. It is very probable that in Scorpio they do not serve merely to secrete a digestive fluid (shown in other Arthropoda to resemble the pancreatic fluid), but that they also become distended by the juices of the prey sucked in by the Scorpion—as certainly must occur in the case of the simple unbranched gastric cæca of the Spiders.

The most important difference which exists between the structure of Limulus and that of Scorpio is found in the hinder region of the alimentary canal. Scorpio is here provided with a single or double pair of renal excretory tubes, which have been identified by earlier authors with the Malpighian tubes of the Hexapod and Myriapod insects. Limulus is devoid of any such tubes. We shall revert to this subject below.

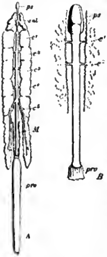


FIG. 33.—The alimentary canal and gastric glands of a Scorpion (A) and of Limulus (B). *ps*, Muscular suctorial enlargement of the pharynx; *sal*, prosomatic pair of gastric cæca in Scorpio, called salivary glands by some writers; c^1, and c^2, the anterior two pairs of gastric cæca and ducts of the mesosomatic region; c^3, c^4, and c^5, cæca and ducts of Scorpio not represented in Limulus; M, the Malpighian or renal cæcal diverticula of Scorpio; *pro*, the proctodæum or portion of gut leading to anus and formed embryologically by an inversion of the epiblast at that orifice. (From Lankester, "Limulus an Arachnid.")

7. *Ovaries and Spermaries: Gonocœls and Gonoducts.*—The scorpion is remarkable for having the specialized portion of cœlom from the walls of which egg-cells or sperm-cells are developed according to sex, in the form of a simple but extensive network. It is not a pair of simple tubes, nor of dendriform tubes, but a closed net-work. The same fact is true of Limulus, as was shown by Owen (7) in regard to the ovary, and by Benham (14) in regard to the testis. This is a very definite and remarkable agreement, since such a reticular gonocœl is not found in Crustacea (except in the male Apus). Moreover, there is a significant agreement in the character of the spermatozoa of Limulus and Scorpio. The Crustacea are—with the exception of the Cirrhipedia—remarkable for having stiff, motionless spermatozoids. In Limulus Lankester found (15) the spermatozoa to possess active flagelliform "tails," and to resemble very closely those of Scorpio which, as are those of most terrestrial Arthropoda, are actively motile. This is a microscopic point of agreement, but is none the less significant.

In regard to the important structures concerned with the fertilization of the egg, Limulus and Scorpio differ entirely from one another. The eggs of Limulus are fertilized in the sea after they have been laid. Scorpio, being a terrestrial animal, fertilizes by copulation. The male possesses elaborate copulatory structures of a chitinous nature, and the eggs are fertilized in the female without even quitting the place where they are formed on the wall of the reticular gonocœl. The female scorpion is viviparous, and the young are produced in a highly developed condition as fully formed scorpions.

Differences between Limulus and Scorpio.—We have now passed in review the principal structural features in which Limulus agrees with Scorpio and differs from other Arthropoda. There remains for consideration the one important structural difference between the two animals. Limulus agrees with the majority of the Crustacea in being destitute of renal excretory cæca or tubes opening into the hinder part of the gut. Scorpio, on the other hand, in common with all air-breathing Arthropoda except Peripatus, possesses these tubules which are often called Malpighian tubes. A great deal has been made of this difference by some writers. It has been considered by them as proving that Limulus, in spite of all its special agreements with Scorpio (which, however, have scarcely been appreciated by the writers in question), really belongs to the Crustacean line of descent, whilst Scorpio, by possessing Malpighian tubes, is declared to be unmistakably tied together with the other Arachnida to the tracheate Arthropods, the Hexapods, Diplopods, and Chilopods, which all possess Malpighian tubes.

It must be pointed out that the presence or absence of such renal excretory tubes opening into the intestine appears to be a question of adaptation to the changed physiological conditions of respiration, and not of morphological significance, since a pair of renal excretory tubes of this nature is found in certain Amphipod Crustacea (Talorchestia, &c.) which have abandoned a purely aquatic life. This view has been accepted and supported by Professors Korschelt and Heider (16). An important fact in its favour was discovered by Laurie (17), who investigated the embryology of two species of Scorpio under Lankester's direction. It appears that the Malpighian tubes of Scorpio are developed from the mesenteron, viz., that portion of the gut which is formed by the hypoblast, whereas in Hexapod insects the similar cæcal tubes are developed from the proctodæum or in-pushed portion of the gut which is formed from epiblast. In fact it is not possible to maintain that the renal excretory tubes of the gut are of one common origin in the Arthropoda. They have appeared independently in connexion with a change in the excretion of nitrogenous waste in Arachnids, Crustacea, and the other classes of Arthropoda when aerial, as opposed to aquatic, respiration has been established—and they have been formed in some cases from the mesenteron, in other cases from the proctodæum. Their appearance in the air-breathing Arachnids does not separate those forms from the water-breathing Arachnids which are devoid of them, any more than does their appearance in certain Amphipoda separate those Crustaceans from the other members of the class.

Further, it is pointed out by Korschelt and Heider that the hinder portion of the gut frequently acts in Arthropoda as an organ of nitrogenous excretion in the absence of any special excretory tubules, and that the production of such cæca from its surface in separate lines of descent does not involve any elaborate or unlikely process of growth. In other words, the Malpighian tubes of the terrestrial Arachnida are *homoplastic* with those of Hexapoda and Myriapoda, and not *homogenetic* with them. We are compelled to take a similar view of the agreement between the tracheal air-tubes of Arachnida and other tracheate Arthropods. They are homoplasts (see **18**) one of another, and do not owe their existence in the various classes compared to a common inheritance of an ancestral tracheal system.

Conclusions arising from the Close Affinity of Limulus and Scorpio.—When we consider the relationships of the various classes of Arthropoda, having accepted and established the fact of the close genetic affinity of Limulus and Scorpio, we are led to important conclusions. In such a consideration we have to make use not only of the fact just mentioned, but of three important generalizations which serve as it were as implements for the proper estimation of the relationships of any series of organic forms. First of all there is the generalization that the relationships of the various forms of animals (or of plants) to one another is that of the ultimate twigs of a much-branching genealogical tree. Secondly, identity of structure in two organisms does not necessarily indicate that the identical structure has been inherited from an ancestor common to the two organisms compared (homogeny), but may be due to independent development of a like structure in two different lines of descent (homoplasy). Thirdly, those members of a group which, whilst exhibiting undoubted structural characters indicative of their proper assignment to that group, yet are simpler than and inferior in elaboration of their organization to other members of the group, are not necessarily representatives of the earlier and primitive phases in the development of the group—but are very often examples of retrogressive change or degeneration. The second and third implements of analysis above cited are of the nature of cautions or checks. Agreements are not *necessarily* due to common inheritance; simplicity is not *necessarily* primitive and ancestral.

On the other hand, we must not rashly set down agreements as due to "homoplasy" or "convergence of development" if we find two or three or more concurrent agreements. The probability is against agreement being due to homoplasy when the agreement involves a number of really separate (not correlated) coincidences. Whilst the chances are in favour of some *one* homoplastic coincidence or structural agreement occurring between some member or other of a large group *a* and some member or other of a large group *b*, the matter is very different when by such an initial coincidence the two members have been particularized. The chances against these two selected members exhibiting *another* really independent homoplastic agreement are enormous: let us say 10,000 to 1. The chances against yet another coincidence are a hundred million to one, and against yet one more "coincidence" they are the square of a hundred million to one. Homoplasy can only be assumed where the coincidence is of a simple nature, and is such as may be reasonably supposed to have arisen by the action of like selective conditions upon like material in two separate lines of descent.[1]

So, too, degeneration is not to be lightly assumed as the explanation of a simplicity of structure. There is a very definite criterion of the simplicity due to degeneration, which can in most cases be applied. Degenerative simplicity is never uniformly distributed over all the structures of the organism. It affects many or nearly all the structures of the body, but leaves some, it may be only one, at a high level of elaboration and complexity. Ancestral simplicity is more uniform, and does not coexist with specialization and elaboration of a single organ. Further: degeneration cannot be inferred safely by the examination of an isolated case; usually we obtain a series of forms indicating the steps of a change in structure—and what we have to decide is whether the movement has been from the simple to the more complex, or from the more complex to the simple. The feathers of a peacock afford a convenient example of primitive and degenerative simplicity. The highest point of elaboration in colour, pattern, and form, is shown by the great eye-painted tail feathers. From these we can pass by gradual transitions in two directions, viz., either to the simple lateral tail feathers with a few rami only, developed only on one side of the shaft and of uniform metallic coloration—or to the simple contour feathers of small size, with the usual symmetrical series of numerous rami right and left of the shaft and no remarkable colouring. The one-sided specialization and the peculiar metallic colouring of the lateral tail feathers mark them as the extreme terms of a degenerative series, whilst the symmetry, likeness of constituent parts *inter se*, and absence of specialized pigment, as well as the fact that they differ little from any average feather of birds in general, mark the contour feather as primitively simple, and as the starting-point from which the highly elaborated eye-painted tail feather has gradually evolved.

Applying these principles to the consideration of the Arachnida, we arrive at the conclusion that the smaller and simpler Arachnids are not the more primitive, but that the Acari or Mites are in fact a degenerate group. This was maintained by Lankester in 1878 (**19**), again in 1881 (**20**); it was subsequently announced as a novelty by Claus in 1885 (**21**). Though the aquatic members of a class of animals are in some instances derived from terrestrial forms, the usual transition is from an aquatic ancestry to more recent land-living forms. There is no doubt, from a consideration of the facts of structure, that the aquatic water-breathing Arachnids, represented in the past by the Eurypterines and to-day by the sole survivor Limulus, have preceded the terrestrial air-breathing forms of that group. Hence we see at once that the better-known Arachnida form a series, leading from Limulus-like aquatic creatures through Scorpions, Spiders, and Harvestmen, to the degenerate Acari or Mites. The spiders are specialized and reduced in apparent complexity, as compared with the Scorpions, but they cannot be regarded as degenerate since the concentration of structure which occurs in them results in greater efficiency and power than are exhibited by the Scorpion. The determination of the relative degree of perfection of organization attained by two animals compared is difficult when we introduce, as seems inevitable, the question of efficiency and power, and do not confine the question to the perfection of morphological development. We have no measure of the degree of power manifested by various animals—though it would be possible to arrive at some conclusions as to how that "power" should be estimated. It is not possible here to discuss that matter further. We must be content to point out that it seems that the Spiders, the Pedipalps, and other large Arachnids have not been derived from the Scorpions directly, but have independently developed from aquatic ancestors, and from one of these independent groups—probably through the Harvestmen from the Spiders—the Acari have finally resulted.

---

[1] A great deal of superfluous hypothesis has lately been put forward in the name of "the principle of convergence of characters" by a certain school of palæontologists. The horse is supposed by these writers to have originated by separate lines of descent in the Old World and the New, from five-toed ancestors! And the important consequences following from the demonstration of the identity in structure of Limulus and Scorpio are evaded by arbitrary and even phantastic invocations of a mysterious transcendental force which brings about "convergence" irrespective of heredity and selection. Morphology becomes a farce when such assumptions are made.

Leaving that question for consideration in connexion with the systematic statement of the characters of the various groups of Arachnida which follows below, it is well now to consider the following question, viz., seeing that Limulus and Scorpio are such highly developed and specialized forms, and that they seem to constitute as it were the first and second steps in the series of recognized Arachnida—what do we know, or what are we led to suppose with regard to the more primitive Arachnida from which the Eurypterines and Limulus and Scorpio have sprung. Do we know in the recent or fossil condition any such primitive Arachnids? Such a question is not only legitimate, but prompted by the analogy of at least one other great class of Arthropods. The great Arthropod class, the Crustacea, presents to the zoologist at the present day an immense range of forms, comprising the primitive Phyllopods, the minute Copepods, the parasitic Cirrhipedes and the powerful Crabs and Lobsters, and the highly-elaborated Sand-hoppers and Slaters. It has been insisted, by those who accepted Lankester's original doctrine of the direct or genetic affinity of the Chætopoda and Arthropoda, that Apus and Branchipus really come very near to the ancestral forms which connected those two great branches of Appendiculate (Parapodiate) animals. On the other hand, the Land Crabs are at an immense distance from these simple forms. The record of the Crustacean family-tree is in fact a fairly complete one—the lower primitive members of the group are still represented by living forms in great abundance. In the case of the Arachnida, if we have to start their genealogical history with Limulus and Scorpio, we are much in the same position as we should be in dealing with the Crustacea, were the whole of the Entomostraca and the whole of the Arthrostraca wiped out of existence and record. There is no possibility of doubt that the series of forms corresponding in the Arachnidan line of descent, to the forms distinguished in the Crustacean line of descent as the lower grade—the Entomostraca—have ceased to exist, and not only so, but have left little evidence in the form of fossils as to their former existence and nature. It must, however, be admitted as probable that we should find some evidence, in ancient rocks or in the deep sea, of the early more primitive Arachnids. And it must be remembered that such forms must be expected to exhibit, when found, differences from Limulus and Scorpio as great as those which separate Apus and Cancer. The existing Arachnida, like the higher Crustacea, are "monomeristic," that is to say, have a fixed typical number of somites to the body. Further, they are like the higher Crustacea, "somatotagmic," that is to say, they have this limited set of somites grouped in three (or more) "tagmata" or regions of a fixed number of similarly modified somites—each tagma differing in the modification of its fixed number of somites from that characterizing a neighbouring "tagma." The most primitive among the lower Crustacea, on the other hand, for example the Phyllopoda, have not a fixed number of somites, some genera—even allied species—have more, some less, within wide limits; they are "anomomeristic." They also, as is generally the case with anomomeristic animals, do not exhibit any conformity to a fixed plan of "tagmatism" or division of the somites of the body into regions sharply marked off from one another; the head or prosomatic tagma is followed by a trunk consisting of somites which either graduate in character as we pass along the series or exhibit a large variety in different genera, families, and orders, of grouping of the somites. They are anomotagmic, as well as anomomeristic.

When it is admitted—as seems to be reasonable—that the primitive Arachnida would, like the primitive Crustacea, be anomomeristic and anomotagmic, we shall not demand of claimants for the rank of primitive Arachnids agreement with Limulus and Scorpio in respect of the exact number of their somites and the exact grouping of those somites; and when we see how diverse are the modifications of the branches of the appendages both in Arachnida and in other classes of Arthropoda (*q.v.*), we shall not over-estimate a difference in the form of this or that appendage exhibited by the claimant as compared with the higher Arachnids. With those considerations in mind, the claim of the extinct group of the Trilobites to be considered as representatives of the lower and more primitive steps in the Arachnidan genealogy must, it seems, receive a favourable judgment. They differ from the Crustacea in that they have only a single pair of præ-oral appendages, the second pair being definitely developed as mandibles. This fact renders their association with the Crustacea impossible, if classification is to be the expression of genetic affinity inferred from structural coincidence. On the contrary, this particular point is one in which they agree with the higher Arachnida. But little is known of the structure of these extinct animals; we are therefore compelled to deal with such special points of resemblance and difference as their remains still exhibit. They had lateral eyes[1] which resemble no known eyes so closely as the lateral eyes of Limulus. The general form and structure of their prosomatic carapace are in many striking features identical with that of Limulus. The trilobation of the head and body—due to the expansion and flattening of the sides or "pleura" of the tegumentary skeleton—is so closely repeated in the young of Limulus that the latter has been called "the Trilobite stage" of Limulus (Fig. 42 compared with Fig 41). No Crustacean exhibits this trilobite form. But most important of the evidences presented by the Trilobites of affinity with Limulus, and therefore with the Arachnida, is the tendency less marked in some, strongly carried out in others, to form a pygidial or telsonic shield—a fusion of the posterior somites of the body, which is precisely identical in character with the metasomatic carapace of Limulus. When to this is added the fact that a post-anal spine is developed to a large size in some Trilobites (Fig. 38), like that of Limulus and Scorpio, and that lateral spines on the pleura of the somites are frequent as in Limulus, and that neither metasomatic fusion of somites nor post-anal spine, nor lateral pleural spines are found in any Crustacean, nor all three together in any Arthropod besides the Trilobites and Limulus—the claim of the Trilobites to be considered as representing one order of a lower grade of Arachnida, comparable to the grade Entomostraca of the Crustacea, seems to be established.

The fact that the single pair of præ-oral appendages of Trilobites, known only as yet in one genus, is in that particular case a pair of uni-ramose antennæ—does not render the association of Trilobites and Arachnids improbable. Although the præ-oral pair of appendages in the higher Arachnida is usually chelate, it is not always so; in Spiders it is not so; nor in many Acari. The bi-ramose structure of the post-oral limbs, demonstrated by Beecher in the Trilobite Triarthrus, is no more inconsistent with its claim to be a primitive Arachnid than is the foliaceous modification of the limbs in Phyllopods inconsistent with their relationship to the Arthrostracous Crustaceans such as Gammarus and Oniscus.

---

[1] A pair of round tubercles on the labrum (camerostome or hypostoma) of several species of Trilobites has been described and held to be a pair of eyes quite recently (**22**). Sense-organs in a similar position were discovered in Limulus by Patten (**42**) in 1894.

Thus, then, it seems that we have in the Trilobites the representatives of the lower phases of the Arachnidan pedigree. The simple Anomomeristic Trilobite, with its equi-formal somites and equi-formal appendages, is one term of the series which ends in the even more simple but degenerate Acari. Between the two and at the highest point of the arc, so far as morphological differentiation is concerned, stands the Scorpion; near to it in the Trilobite's direction (that is on the ascending side) are Limulus and the Eurypterines—with a long gap, due to obliteration of the record, separating them from the Trilobite. On the other side—tending downwards from the Scorpion towards the Acari—are the Pedipalpi, the Spiders, the Book-Scorpions, the Harvest-men, and the Water-Mites.

The strange Nobody-Crabs or Pycnogonids occupy a place on the ascending half of the arc below the Eurypterines and Limulus. They are strangely modified and degenerate, but seem to be (as explained in the systematic review) the remnant of an Arachnidan group holding the same relation to the Scorpions which the Læmodipoda hold to the Podophthalmate Crustacea.

We have now to offer a classification of the Arachnida and to pass in review the larger groups, with a brief statement of their structural characteristics.

In the bibliography at the close of this article (referred to by leaded arabic numerals in brackets throughout these pages), the titles of works are given which contain detailed information as to the genera and species of each order or sub-order, their geographical distribution and their habits and economy so far as they have been ascertained. The limits of space do not permit of a fuller treatment of those matters here.

TABULAR CLASSIFICATION[1] OF THE ARACHNIDA.

CLASS. ARACHNIDA.

Grade A. ANOMOMERISTICA.
Sub-Class. TRILOBITÆ.
Orders. Not satisfactorily determined.
Grade B. NOMOMERISTICA.
Sub-Class I. PANTOPODA.
Order 1. Nymphonomorpha.
,, 2. Ascorhynchomorpha.
,, 3. Pycnogonomorpha.
Sub-Class II. EU-ARACHNIDA.
Grade *a*. DELOBRANCHIA, Lankester (*vel* HYDROPNEUSTEA, Pocock).
Order 1. Xiphosura.
,, 2. Gigantostraca.
Grade *b*. EMBOLOBRANCHIA, Lankester (*vel* AEROPNEUSTEA, Pocock).
Section a. Pectinifera.
Order 1. Scorpionidea.
Sub-order *a*. Apoxypoda.
,, *b*. Dionychopoda.
Section β. Epectinata.
Order 2. Pedipalpi.
Sub-order *a*. Uropygi.
Tribe 1. Urotricha.
,, 2. Tartarides.
Sub-order *b*. Amblypygi.
Order 3. Araneæ.
Sub-order *a*. Mesothelæ.
,, *b*. Opisthothelæ.
Tribe 1. Mygalomorphæ.
,, 2. Arachnomorphæ.
Order 4. Palpigradi (= Microthelyphonida).
Order 5. Solifugæ (= Mycetophoræ).
Order 6. Pseudoscorpiones (= Chelonethi).
Sub-order *a*. Panctenodactyli.
,, *b*. Hemictenodactyli.
Order 7. Podogona (= Meridogastra).
Order 8. Opiliones.
Sub-order *a*. Laniatores.
,, *b*. Palpatores.
,, *c*. Anepignathi.
Order 9. Rhynchostomi (= Acari).
Sub-order *a*. Cryptostigmata.
,, *b*. Metastigmata.
,, *c*. Prostigmata.
,, *d*. Astigmata.
,, *e*. Vermiformia.
, *f*. Tetrapoda.

CLASS. ARACHNIDA.—Euarthropoda having two prosthomeres (somites which have passed from a post-oral to a præ-oral position), the appendages of the first represented by eyes, of the second by solitary rami which are rarely antenniform, more usually chelate. A tendency is exhibited to the formation of a metasomatic as well as a prosomatic carapace by fusion of the tergal surfaces of the somites. Intermediate somites forming a mesosome occur, but tend to fuse superficially with the metasomatic carapace or to become co-ordinated with the somites of the metasoma, whether fused or distinct to form one region, the opisthosoma (abdomen of authors). In the most highly-developed forms the two anterior divisions (tagmata) of the body, prosoma and mesosoma, each exhibit six pairs of limbs, pediform and plate-like respectively, whilst the metasoma consists of six limbless somites and a post-anal spine. The genital apertures are placed in the first somite following the prosoma, excepting where a prægenital somite, usually suppressed, is retained. Little is known of the form of the appendages in the lowest archaic Arachnida, but the tendency of those of the prosomatic somites has been (as in the Crustacea) to pass from a generalized bi-ramose or multi-ramose form to that of uni-ramose antennæ, chelæ, and walking-legs.

The Arachnida are divisible into two grades of structure—according to the fixity or non-fixity of the number of somites building up the body:—

Grade A (of the Arachnida). ANOMOMERISTICA.—Extinct archaic Arachnida, in which (as in the Entomostracous Crustacea) the number of well-developed somites may be more or less than eighteen and may be grouped only as head (prosoma) and trunk or may be further differentiated. A telsonic tergal shield of greater or less size is always present, which may be imperfectly divided into well-marked but immovable tergites indicating incompletely differentiated somites. The single pair of palpiform appendages in front of the mouth has been found in one instance to be antenniform, whilst the numerous post-oral appendages in the same genus were bi-ramose. The position of the genital apertures is not known. Compound lateral eyes present; median eyes wanting. The body and head have the two pleural regions of each somite flattened and expanded on either side of the true gut-holding body-axis. Hence the name of the sub-class signifying tri-lobed, a condition realized also in the Xiphosurous Arachnids. The members of this group, whilst resembling the lower Crustacea (as all lower groups of a branching genealogical tree must do), differ from them essentially in that the head exhibits only one prosthomere (in addition to the eye-bearing prosthomere) with palpiform appendages (as in all Arachnida) instead of two. The Anomomeristic Arachnida form a single sub-class, of which only imperfect fossil remains are known.

Sub-class (of the Anomomeristica). TRILOBITÆ.—The single sub-class Trilobitæ constitutes the grade Anomomeristica. It has been variously divided into orders by a number of writers. The greater or less evolution and specialization of the metasomatic carapace appears to be the most important basis for classification—but this has not been made use of in the latest attempts at drawing up a system of the Trilobites. The form of the middle and lateral regions of the prosomatic shield has been used, and an excessive importance attached to the demarcation of certain areas in that structure. Sutures are stated to mark off some of these, pieces but in the proper sense of that term as applied to the skeletal structures of the Vertebrata, no sutures exist in the chitinous cuticle of Arthropoda. That any partial fusion of originally distinct chitinous plates takes place in the cephalic shield of Trilobites, comparable to the partial fusion of bony pieces by suture in Vertebrata, is a suggestion contrary to fact.

---

[1] The writer is indebted to Mr R. I. Pocock, assistant in the Natural History departments of the British Museum, for valuable assistance in the preparation of this article and for the classification and definition of the groups of Eu-arachnida here given. The general scheme and some of the details have been brought by the writer into agreement with the views maintained in this article. Mr Pocock accepts those views in all essential points and has, as a special student of the Arachnida, given to them valuable expansion and confirmation. The writer also desires to express his thanks to Messrs. Macmillan for permission to use Figs. 22, 43, 44, and 45, which are taken from Parker and Haswell's *Text-book of Zoology*; and to Messrs. Swan Sonnenschein and Co. for the loan of several figures from the translations published by them of the admirable treatise on *Embryology* by Professors Korschelt and Heider; also to the publishers of the treatise on *Palæontology* by Professor Zittel, Herr Oldenbourg and Macmillan and Co. of New York for several cuts of extinct forms.

The Trilobites are known only as fossils, mostly Silurian and pre-Silurian; a few are found in Carboniferous and Permian strata. As many as two thousand species are known. Genera with small metasomatic carapace, consisting of three to six fused segments distinctly marked though not separated by soft membrane, are Harpes, Paradoxides, and Triarthrus (Fig. 34). In Calymene, Homalonotus and Phacops (Fig. 38) from six to sixteen segments are clearly marked by ridges and grooves in the metasomatic tagma, whilst in Illaenus the shield so formed is large but no somites are marked out on its surface. In this genus ten free somites (mesosoma) occur between the prosomatic and metasomatic carapaces. Asaphus and Megalaspis (Fig. 39) are similarly constituted. In Agnostus (Fig. 40) the anterior and posterior carapaces constitute almost the entire body, the two carapaces being connected by a mid-region of only two free somites. It has been held that the forms with a small number of somites marked in the posterior carapace and numerous free somites between the anterior and posterior carapace, must be considered as anterior to those in which a great number of posterior somites are traceable in the metasomatic carapace, and that those in which the traces of distinct somites in the posterior or metasomatic carapace are most completely absent must be regarded as derived from those in which somites are well marked in the posterior carapace and similar in appearance to the free somites. The genus Agnostus, which belongs to the last category, occurs abundantly in Cambrian strata and is one of the earliest forms known. This would lead to the supposition that the great development of metasomatic carapace is a primitive and not a late character, were it not for the fact that Paradoxides and Atops, with an inconspicuous telsonic carapace and numerous free somites, are also Cambrian in age, the latter indeed anterior in horizon to Agnostus.

On the other hand, it may well be doubted whether the pygidial or posterior carapace is primarily due to a fusion of the tergites of somites which were previously movable and well developed. The posterior carapace of the Trilobites and of Limulus is probably enough in origin a telsonic carapace—that is to say is the tergum of the last segment of the body which carries the anus. From the front of this region new segments are produced in the first instance, and are added during growth to the existing

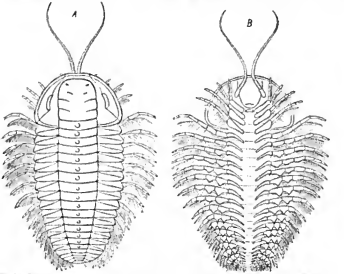


Fig. 34.—Restoration of *Triarthrus Becki*, Green, as determined by Mr. Beecher from specimens obtained from the Utica Slates (Ordovician), New York. A, dorsal; B, ventral surface. In the latter the single pair of antennae springing up from each side of the camerostome or hypostome or upper lip-lobe are seen. Four pairs of appendages besides these are seen to belong to the cephalic tergum. All the appendages are pediform and bi-ramose; all have a prominent gnathobase, and in all the exopodite carries a comb-like series of secondary processes. (After Beecher, from Zittel.)

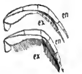


Fig. 36.—*Triarthrus Becki*, Green. Dorsal view of second thoracic leg with and without setae. en, Inner ramus; ex, outer ramus. (After Beecher.)

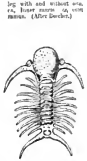


Fig. 37.—*Deiphon Forbesii*, Barr. One of the Cheiruridae. Silurian Bohemia. (From Zittel's *Palaeontology*.)

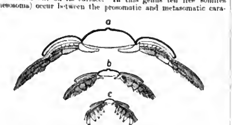


Fig. 35.—*Triarthrus Becki*, Green. *a*, Restored thoracic limbs in transverse section of the animal; *b*, section across a posterior somite; *c*, section across one of the sub-terminal somites. (After Beecher.)

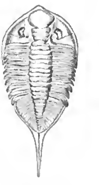


Fig. 38.—*Dalmanites limulurus*, Green. One of the Phacopidae, from the Silurian, New York. (From Zittel.)

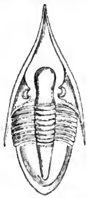


Fig. 39.—*Megalaspis extenuata*. One of the Asaphidae allied to Illaenus, from the Ordovician of East Gothland, Sweden. (From Zittel.)

series. This telson may enlarge, it may possibly even become internally and externally developed as partially separate somites, and the tergum may remain without trace of somite formation, or, as appears to be the case in Limulus, the telson gives rise to a few well-marked somites (mesosoma and two others) and then enlarges without further trace of segmentation, whilst the chitinous integument which develops in increasing thickness on the terga as growth advances welds together the unsegmented telson and the somites in front of it, which were previously marked by separate tergal thickenings. It must always be remembered that we are liable (especially in the case of fossilized integuments) to attach an unwarranted interpretation to the mere discontinuity or continuity of the thickened plates of chitinous cuticle on the back of an Arthropod. These plates may fuse, and yet the somites to which they belong may remain distinct, and each have its pair of appendages well developed.

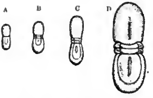


Fig. 40.—Four stages in the development of the trilobite *Agnostus nudus*. A, youngest stage with no mesosomatic somites; B and C, stages with two mesosomatic somites between the prosomatic and telsonic carapaces; D, adult condition, still with only two free mesosomatic somites. (From Korschelt and Heider.)

On the other hand, an unusually large tergal plate, whether terminal or in the series, is not always due to fusion of the dorsal plates of once-separate somites, but is often a case of growth and enlargement of a single somite without formation of any trace of a new somite. For the literature of Trilobites see (**22°**).

Grade B (of the Arachnida) NOMOMERISTICA.—Arachnida in which, excluding from consideration the eye-bearing prosthomere, the somites are primarily (that is to say, in the common ancestor of the grade) grouped in three regions of six—(*a*) the "prosoma" with palpiform appendages, (*b*) the "mesosoma" with plate-like appendages, and (*c*) the "metasoma" with suppressed appendages. A somite placed between the prosoma and mesosoma—the pre-genital somite—appears to have belonged originally to the prosomatic series (which with its ocular prosthomere and palpiform limbs [Pantopoda], would thus consist of eight somites), but to have been gradually reduced. In living Arachnids, excepting the Pantopoda, it is either fused (with loss of its appendages) with the prosoma (Limulus,[1] Scorpio), after embryonic appearance, or is retained as a rudimentary, separate, detached somite in front of the mesosoma, or disappears altogether (excalation). The atrophy and total disappearance of ancestrally well-marked somites frequently take place (as in all Arthropoda) at the posterior extremity of the body, whilst excalation of somites may occur at the constricted areas which often separate adjacent "regions," though there are very few instances in which it has been recognized. Concentration of the organ-systems by fusion of neighbouring regions (prosoma, mesosoma, metasoma), previously distinct, has frequently occurred, together with obliteration of the muscular and chitinous structures indicative of distinct somites. This concentration and obliteration of somites, often accompanied by dislocation of important segmental structures (such as appendages and nerve-ganglia), may lead to highly-developed specialization (individuation, H. Spencer), as in the Araneæ and Opiliones, and, on the other hand, may terminate in simplification and degeneration, as in the Acari.

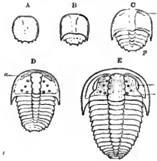


Fig. 41.—Five stages in the development of the trilobite *Sao hirsuta*. A, youngest stage; B, older stage with distinct pygidial carapace; C, stage with two free mesosomatic somites between the prosomatic and telsonic carapaces; D, stage with seven free intermediate somites; E, stage with twelve free somites; the telsonic carapace has not increased in size; a, lateral eye; g, so-called facial "suture" (not really a suture); p, telsonic carapace. (From Korschelt and Heider, after Barrande.)

The most important general change which has affected the structure of the nomomeristic Arachnida in the course of their historic development is the transition from an aquatic to a terrestrial life. This has been accompanied by the conversion of the lamelliform gill-plates into lamelliform lung-plates, and later the development from the lung-chambers, and at independent sites, of tracheæ or air-tubes (by adaptation of the vasifactive tissue of the blood-vessels) similar to those independently developed in Peripatus, Diplopoda, Hexapoda, and Chilopoda. Probably tracheæ have developed independently by the same process in several groups of tracheate Arachnids. The nomomeristic Arachnida comprise two sub-classes—one a very small degenerate offshoot from early ancestors; the other, the great bulk of the class.

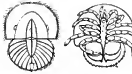


Fig. 42.—So-called "trilobite stage" of *Limulus polyphemus*. A, dorsal, B, ventral view. (From Korschelt and Heider, after Leuckart.)

Sub-Class I (of the Nomomeristica). PANTOPODA.—Nomomeristic Arachnids, in which the somites corresponding to mesosoma and metasoma have entirely aborted. The seventh leg-bearing somite (the pre-genital rudimentary somite of Eu-arachnida) is present and has its leg-like appendages fully developed. Monomeniscous eyes with a double (really triple) cell-layer formed by invagination, as in the Eu-arachnida, are present. The Pantopoda stand in the same relation to Limulus and Scorpio that Cyamus holds to the thoracostracous Crustacea. The reduction of the organism to seven leg-bearing somites, of which the first pair, as in so many Eu-arachnida, are chelate, is a form of degeneration connected with a peculiar quasi-parasitic habit resembling that of the crustacean Læmodipoda. The genital pores are situate at the base of the 7th pair of limbs, and may be repeated on the 4th, 5th, and 6th. In all known Pantopoda the size of the body is quite minute as compared with that of the limbs: the alimentary canal sends a long cæcum into each leg (*cf.* the Araneæ) and the genital products are developed in gonocœls also placed in the legs.

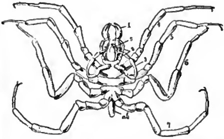


Fig. 43.—One of the Nymphonomorphous Pantopoda, *Nymphon hispidum*, showing the seven pairs of appendages 1 to 7; *ab*, the rudimentary opisthosoma; *s*, the mouth-bearing proboscis. (From Parker and Haswell's *Text-book of Zoology*, after Hoek.)

The Pantopoda are divided into three orders, the characters of which are dependent on variation in the presence of the full number of legs.

Order 1 (of the Pantopoda). Nymphonomorpha, Pocock (nov.) (Fig. 43).—In primitive forms belonging to the family Nymphonidæ the full complement of appendages is retained—the 1st (mandibular), the 2nd (palpiform), and the 3rd (ovigerous) pairs being well developed in both sexes. In certain derivative forms constituting the family Pallenidæ, however, the appendages of the 2nd pair are either rudimentary or atrophied altogether.

Two families: 1. Nymphonidæ (genus *Nymphon*), and 2. Pallenidæ (genus *Pallene*).

---

[1] Mr Pocock suggests that the area marked vii. in the outline figure of the dorsal view of Limulus (Fig. 7) may be the tergum of the suppressed pre-genital somite. Embryological evidence must settle whether this is so or not.

Order 2. Ascorhynchomorpha, Pocock (nov.).—Appendages of the 2nd and 3rd pairs retained and developed, as in the more primitive types of Nymphonomorpha; but those of the 1st pair are either rudimentary, as in the Ascorhynchidæ, or atrophied, as in the Colossendeidæ. In the latter a further specialization is shown in the fusion of the body segments.

Two families: 1. Ascorhynchidæ (genera *Ascorhynchus* and *Ammothea*); 2. Colossendeidæ (genera *Colossendeis* and *Discoarachne*).

Order 3. Pycnogonomorpha, Pocock (nov.).—Derivative forms in which the reduction in number of the anterior appendages is carried farther than in the other orders, reaching its extreme in the Pycnogonidæ, where the 1st and 2nd pairs are absent in both sexes and the 3rd pair also are absent in the female. In the Hannoniidæ, however, which resemble the Pycnogonida in the absence of the 3rd pair in the female and of the 2nd pair in both sexes, the 1st pair are retained in both sexes.

Two families: 1. Hannoniidæ (genus *Hannonia*); 2. Pycnogonidæ (genera *Pycnogonum* and *Phoxichilus*).

Remarks.—The Pantopoda are not known in the fossil condition. They are entirely marine, and are not uncommon in the coralline zone of the sea-coast. The species are few, not more than fifty (**23**). Some large species of peculiar genera are taken at great depths. Their movements are extremely sluggish. They are especially remarkable for the small size of the body and the extension of viscera into the legs. Their structure is eminently that of degenerate forms. Many frequent growths of coralline Algæ and Hydroid polyps, upon the juices of which they feed, and in some cases a species of gall is produced in Hydroids by the penetration of the larval Pantopod into the tissues of the polyp.

Sub-Class II (of the Nomomeristic Arachnida). EU-ARACHNIDA.—These start from highly developed and specialized aquatic branchiferous forms, exhibiting prosoma with six pediform pairs of appendages, an intermediate pre-genital somite, a mesosoma of six somites bearing lamelliform pairs of appendages, and a metasoma of six somites devoid of appendages, and the last provided with a post-anal spine. Median eyes are present, which are monomeniscous, with distinct retinal and corneagenous cell-layers, and placed centrally on the prosoma. Lateral eyes also may be present, arranged in lateral groups, and having a single or double cell-layer beneath the lens. The first pair of limbs is often chelate or prehensile, rarely antenniform; whilst the second, third, and fourth may also be chelate, or may be simple palps or walking legs.

An internal skeletal plate, the so-called "entosternite" of fibro-cartilaginous tissue, to which many muscles are attached, is placed between the nerve-cords and the alimentary tract in the prosoma of the larger forms (Limulus, Scorpio, Mygale). In the same and other leading forms a pair of much-coiled glandular tubes, the coxal glands (cœlomocœls in origin), is found with a duct opening on the coxa of the fifth pair of appendages of the prosoma. The vascular system is highly developed (in the non-degenerate forms); large arterial branches closely accompany or envelop the chief nerves; capillaries are well developed. The blood-corpuscles are large amœbiform cells, and the blood-plasma is coloured blue by hæmocyanin.

The alimentary canal is uncoiled and cylindrical, and gives rise laterally to large gastric glands, which are more than a single pair in number (two to six pairs), and may assume the form of simple cæca. The mouth is minute and the pharynx is always suctorial, never gizzard-like. The gonadial tubes (gonocœls or gonadial cœlom) are originally reticular and paired, though they may be reduced to a simpler condition. They open on the first somite of the mesosoma. In the numerous degenerate forms simplification occurs by obliteration of the demarcations of somites and the fusion of body-regions, together with a gradual suppression of the lamelliferous respiratory organs and the substitution for them of tracheæ, which, in their turn, in the smaller and most reduced members of the group, may also disappear.

The Eu-arachnida are divided into two grades with reference to the condition of the respiratory organs as adapted to aquatic or terrestrial life.

Grade *a* (of the Eu-arachnida). DELOBRANCHIA (Hydropneustea).

Mesosomatic segments furnished with large plate-like appendages, the 1st pair acting as the genital operculum, the remaining pairs being provided with branchial lamellæ fitted for breathing oxygen dissolved in water. The pre-genital somite partially or wholly obliterated in the adult. The mouth lying far back, so that the basal segments of all the prosomatic appendages, excepting those of the 1st pair, are capable of acting as masticatory organs. Lateral eyes consisting of a densely-packed group of eye-units ("compound" eyes).

Order 1. Xiphosura.—The pre-genital somite fuses in the embryo with the prosoma and disappears (see Fig. 19). Not free-swimming, none of the prosomatic appendages modified to act as paddles; segments of the mesosoma and metasoma (= opisthosoma) not more than ten in number, distinct or coalesced.

Family—Limulidæ (*Limulus*).
,, Belinuridæ (*Belinurus*, *Aglaspis*, *Prestwichia*).
,, Hemiaspidæ (*Hemiaspis*, *Bunodes*).

Remarks.—The Xiphosura are marine in habit, frequenting the shore. They are represented at the present day by the single genus Limulus (Figs. 44 and 45; also Figs. 7, 9, 11, to 15 and 20), which occurs on the American coast of the Atlantic Ocean, but not on its eastern coasts, and on the Asiatic coast of the Pacific. The Atlantic

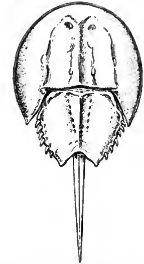


FIG. 44.—Dorsal view of *Limulus polyphemus*, Latr. One-fourth the natural size, linear. (From Parker and Haswell, *Text-book of Zoology*, after Leuckart.)

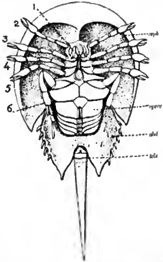


FIG. 45.—Ventral view of *Limulus polyphemus*, one-fourth the natural size, linear. 1 to 6, the six prosomatic pairs of appendages; *abd*, the solid opisthosomatic carapace; *tels*, the post-anal spine (not the telson as the lettering would seem to imply, but only its post-anal portion); *operc*, the fused first pair of mesosomatic appendages forming the genital operculum. (From Parker and Haswell, *Text-book of Zoology*, after Leuckart.)

species (*L. polyphemus*) is common on the coasts of the United States, and is known as the King-Crab or Horse-shoe Crab. A single specimen was found in the harbour of Copenhagen in the 18th century, having presumably been carried over by a ship to which it clung.

A species of Limulus is found in the Buntersandstein of the Vosges; L. Walchi is abundant in the Oolitic lithographic slates of Bavaria.

The genera Belinurus, Aglaspis, Prestwichia, Hemiaspis, and Bunodes consist of small forms which occur in Palæozoic rocks. In none of them are the appendages known, but in the form of the two carapaces and the presence of free somites they are distinctly intermediate between Limulus and the Trilobitæ. The young form of Limulus itself (Fig. 40) is also similar to a Trilobite so far as its segmentation and trilobation are concerned. The lateral eyes of Limulus appear to be identical in structure and position with those of certain Trilobitæ.

Order 2. Gigantostraca (Figs. 46, 47).—Free-swimming forms, with the appendages of the 6th or 5th and 6th pairs flattened or lengthened to act as oars; segments of mesosoma and metasoma (=opisthosoma), twelve in number.

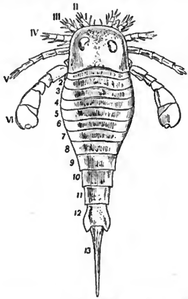


Fig. 46.—*Eurypterus Fischeri*, Eichwald. Silurian of Rootzikil. Restoration after Schmidt, half the size of nature. The dorsal aspect is presented showing the prosomatic shield with paired compound eyes and the prosomatic appendages II to VI. The small first pair of appendages is concealed from view by the carapace. 1 to 12 are the somites of the opisthosoma; 13, the post-anal spine. (From Zittel's *Text-book of Palæontology*. Macmillans, New York, 1896.)

Appendages of anterior pair very large and chelate.

Sub-order Pterygotomorpha, Pterygotidæ (*Pterygotus*).

Appendages of anterior pair minute and chelate.

Sub-order Eurypteromorpha { Stylonuridæ (*Stylonurus*).
Eurypteridæ (*Eurypterus*, *Slimonia*).

Remarks.—The Gigantostraca are frequently spoken of as "the Eurypterines." Not more than thirty species are known. They became extinct in Palæozoic times, and are chiefly found in the Upper Silurian, though extending upwards as far as the Carboniferous. They may be regarded as "macrourous" Xiphosura; that is to say, Xiphosura in which the nomomeristic number of eighteen well-developed somites is present and the posterior ones form a long tail-like region of the body. There still appears to be some doubt whether in the sub-order Eurypteromorpha the first pair of prosomatic appendages (Fig. 46) is atrophied, or whether, if present, it has the form of a pair of tactile palps or of minute chelæ. Though there are indications of lamelliform respiratory appendages on mesosomatic somites following that bearing the genital operculum, we cannot be said to have any proper knowledge as to such appendages, and further evidence with regard to them is much to be desired. (For literature see Zittel, **22*.**)

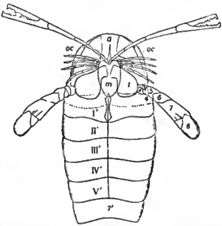


Fig. 47.—*Pterygotus osiliensis*, Schmidt. Silurian of Rootzikil. Restoration of the ventral surface, one-third the natural size, after Schmidt. *a*, camerostome or epistoma; *m*, chilarium or metasternite of the prosoma (so-called metastoma); *oc*, the compound eyes; 1 to 8, segments of the sixth prosomatic appendage; I' to V', first five opisthosomatic somites; 7', sixth opisthosomatic somite. Observe the powerful gnathobases of the sixth pair of prosomatic limbs and the median plates behind *m*. The dotted line on somite I indicates the position of the genital operculum which was probably provided with branchial lamellæ. (From Zittel's *Palæontology*.)

Grade *b* (of the Eu-arachnida). EMBOLOBRANCHIA (Aeropneustea).

In primitive forms the respiratory lamellæ of the appendages of the 3rd, 4th, 5th, and 6th, or of the 1st and 2nd mesosomatic somites are sunk beneath the surface of the body, and become adapted to breathe atmospheric oxygen, forming the leaves of the so-called lung-books. In specialized forms these pulmonary sacs are wholly or partly replaced by tracheal tubes. The appendages of the mesosoma generally suppressed; in the more primitive forms one or two pairs may be retained as organs subservient to reproduction or silk-spinning. Mouth situated more forwards than in Delobranchia, no share in mastication being taken by the basal

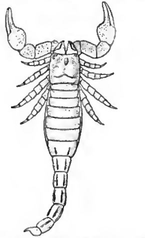


Fig. 48.—Dorsal view of a restoration of *Palæophonus nuncius*, Thorell. The Silurian Scorpion from Gothland. (Restored after Thorell's indications by Mr. R. I. Pocock.)

segments of the 5th and 6th pairs of prosomatic appendages. Lateral eyes, when present, represented by separate ocelli.

The pre-genital somite, after appearing in the embryo, either is obliterated (Scorpio, Galeodes, Opilio, and others) or is retained as a reduced narrow region of the body, the "waist," between prosoma and mesosoma. It is represented by a full-sized tergal plate in the Pseudo-scorpiones.

Section a. *Pectinifera*.—The primitive distinction between the mesosoma and the metasoma retained, the latter consisting of six somites and the former of six somites in the adult, each of which is furnished during growth with a pair of appendages. Including the pre-genital somite (Fig. 16), which is suppressed in the adult, there are thirteen somites behind the prosoma. The appendages of the 1st and 2nd mesosomatic somites persisting as the genital operculum and pectones respectively, those of the 3rd, 4th, 5th, and 6th somites (? in *Palæophonus*) sinking below the surface during growth in connexion with the formation of the four pairs of pulmonary sacs (see Fig. 17). Lateral eyes monostichous.

Order 1. Scorpionidea.—Prosoma covered by a single dorsal shield, bearing typically median and lateral eyes; its sternal elements reduced to a single plate lodged between or behind the basal segments of the 5th and 6th pairs of appendages. Appendages of 1st pair tri-segmented, chelate; of 2nd pair chelate, with their basal segments subserving mastication; of 3rd, 4th, 5th, and 6th pairs similar in form and function, except that in recent and Carboniferous forms the basal segments of the 3rd and 4th are provided with sterno-coxal (maxillary) lobes, those of the 4th pair meeting in the middle line and underlying the mouth. The five posterior somites of the metasoma constricted to form a "tail," the post-anal sclerite persisting as a weapon of offence and provided with a pair of poison glands (see Figs. 8, 10, 12, 13, 14, 15, 21, and 22).

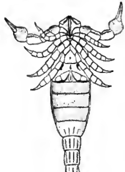


FIG. 49.—Ventral view of a restoration of *Palæophonus Hunteri*, Pocock, the Silurian Scorpion from Lesmahago, Scotland. Restored by Mr. R. I. Pocock. The meeting of the coxæ of all the prosomatic limbs in front of the pentagonal sternum; the space for a genital operculum; the pair of pectens, and the absence of any evidence of pulmonary stigmata are noticeable in this specimen. (See Pocock, *Quart. Jour. Micr. Sci.* 1901.)

Sub-order Apoxypoda.—The 3rd, 4th, 5th, and 6th pairs of appendages short, stout, tapering, the segments about as wide as long, except the apical, which is distally slender, pointed, slightly curved, and without distinct movable claws.

Family—Palæophonidæ, Palæophonus (Figs. 48 and 49).

Sub-order Dionychopoda.—The 3rd, 4th, 5th, and 6th pairs of appendages slender, not evenly tapering, the segments longer than wide; the apical segment short, distally truncate, and provided with a pair of movable claws. Basal segments of the 5th and 6th pairs of appendages abutting against the sternum of the prosoma (see Fig. 10 and Figs. 51, 52, and 53).

Family—Pandinidæ (*Pandinus, Opisthophthalmus, Urodacus*).
,, Vejovidæ (*Vejovis, Jurus, Euscorpius, Broteas*).
,, Bothriuridæ (*Bothriurus, Cercophonius*).
,, Buthidæ (*Buthus, Centrurus*).
,, *Cyclophthalmidæ (*Cyclophthalmus*) } Carbon-
,, *Eoscorpiidæ (*Eoscorpius, Centromachus* } iferous.

Remarks on the Order Scorpionidea.—The Scorpion is one of the great animals of ancient lore and tradition. It and the crab are the only two invertebrates which had impressed the minds of early men sufficiently to be raised to the dignity of astronomical representation. It is all the more remarkable that the scorpion proves to be the oldest animal form of high elaboration which has persisted to the present day. In the Upper Silurian two specimens of a scorpion have been found (Figs. 48, 49), one in Gothland and one in Scotland, which would be recognized at once as true scorpions by a child or a savage. The Silurian scorpion, *Palæophonus*, differs, so far as obvious points are concerned, from a modern scorpion only in the thickness of its legs and in their terminating in strong spike-like joints, instead of being slight and provided with a pair of terminal claws. The legs of the modern scorpion (Fig. 10: Fig. 51) are those of a terrestrial Arthropod, such as a beetle; whilst those of the Silurian scorpion are the legs of an aquatic Arthropod, such as a crab or lobster. It is probable that the Silurian scorpion was an aquatic animal, and that its respiratory lamellæ were still projecting from the surface of the body to serve as branchiæ. No trace of "stigmata," the orifices of the lung chambers of modern scorpions, can be found in the Scottish specimen of Palæophonus, which presents the ventral surface of the animal to view. On the other hand, no trace of respiratory appendages excepting the pectens can be detected in the specimen (see Fig. 49).

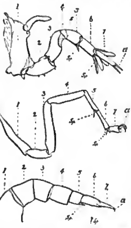


FIG. 50.—Comparison of the sixth prosomatic limb of a recent Scorpion (B), of Palæophonus (C), and of Limulus (A), showing their agreement in the number of segments; in the existence of a movable spine, Sp, at the distal border of the 5th segment; in the correspondence of the two claws at the free end of the limb of Scorpio with two spines similarly placed in Limulus; and, lastly, in the correspondence of the three talon-like spines carried on the distal margin of segment six of recent Scorpions with the four larger but similarly situated spines on the leg of Limulus; *t*, groove dividing the ankylosed segments 4 and 5 of the Limulus leg into two. (After Pocock, *Q. J. Mic. Sci.* 1901.)

Fossil scorpions of the modern type are found in the Coal Measures. At the present day scorpions of various genera are found in all the warm regions of the world. In Europe they occur as far north as Bavaria and the south of France. The largest species measure 9 inches from the front of the head to the end of the sting, and occur in tropical India and Africa. Between 200 and 300 species are known. The scorpions use their large chelæ for seizing prey and for fighting with one another. They never use the sting when (as frequently happens) they attack another scorpion, because, as was ascertained by A. G. Bourne (**24**), the poison exuded by the sting has no injurious effect on another scorpion nor on the scorpion itself. The stories of a scorpion stinging itself to death when placed in a circle of burning coals are due to erroneous observation. When placed in such a position the scorpion faints and becomes inert. It is found (Bourne, **24**) that some species of scorpion faint at a temperature of 40° cent. They recover on being removed to cooler conditions. A scorpion having seized its prey (usually a large insect, or small reptile or

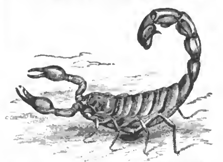


FIG. 51.—Drawing from life of the desert Scorpion, *Buthus australis*, Lin., from Biskra, N. Africa. (From Lankester, *Journ. Linn. Soc. Zool.* vol. xvi. 1881.)

mammal) with the large chelæ brings its tail over its head, and deliberately punctures the struggling victim twice with its sting (Fig. 52). The poison of the sting is similar to snake-poison (Calmette), and rapidly paralyses animals which are not immune to it. It is probably only sickly adults or young children of the human race who can be actually killed by a scorpion's sting. When the scorpion has paralysed its prey in this way, the two short chelicerae are brought into play (Fig. 53). By the crushing action of their pincers, and an alternate backward and forward movement, they bring the soft blood-holding tissues of the victim close to the minute pin-hole aperture which is the scorpion's mouth. The muscles acting on the bulb-like pharynx now set up a pumping action (see Huxley, **26**); and the juices—but no solid matter, excepting such as is reduced to powder—are sucked into the scorpion's alimentary canal. A scorpion appears to prefer for its food another scorpion, and will suck out the juices of an individual as large as itself. When this has taken place, the gorged scorpion becomes distended and tense in the mesosomatic region. It is certain that the absorbed juices do not occupy the alimentary canal alone, but pass also into its cæcal off-sets, which are the ducts of the gastric glands (see Fig. 33).

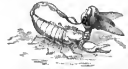


FIG. 52.—Drawing from life of the Italian Scorpion *Euscorpius italicus*, Herbst, holding a blue-bottle fly with its left chela, and carefully piercing it between head and thorax with its sting. Two insertions of the sting are effected and the fly is instantly paralysed by the poison so introduced into its body. (From Lankester, *Journ. Linn. Soc.*)

All Arachnida, including Limulus, feed by suctorial action in essentially the same way as Scorpio.

Scorpions of various species have been observed to make a hissing noise when disturbed, or even when not disturbed. The sound is produced by stridulating organs developed on the basal joints of the limbs, which differ in position and character in different genera (see Pocock, **27**). Scorpions copulate with the ventral surfaces in contact. The eggs are fertilized, practically in the ovary, and develop *in situ*. The young are born fully formed and are carried by the mother on her back. As many as thirty have been counted in a brood. For information as to the embryology of scorpions, the reader is referred to the works named in the bibliography below. Scorpions do not possess spinning organs nor form either snares or nests, so far as is known. But some species inhabiting sandy deserts form extensive burrows. The fifth pair of prosomatic appendages is used by these scorpions when burrowing, to kick back the sand as the burrow is excavated by the great chelæ.

References to works dealing with the taxonomy and geographical distribution of scorpions are given at the end of this article (**28**).

Section β. *Epectinata*.—The primitive distinction between the mesosoma and the metasoma wholly or almost wholly obliterated, the two regions uniting to form an opisthosoma, which never consists of more than twelve somites and never bears appendages or breathing-organs behind the 4th somite. The breathing-organs of the opisthosoma, when present, represented by two pairs of stigmata, opening either upon the 1st and 2nd (Pedipalpi) or the 2nd and 3rd somites (Solifugæ, Pseudo-scorpiones), or by a single pair upon the 3rd (? 2nd) somite (Opiliones) of the opisthosoma, there being rarely an additional stigma on the 4th (some Solifugæ). The appendages of the 2nd somite of the opisthosoma absent, rarely minute and bud-like (some Amblypygi), never pectiniform. A præ-genital somite is often present either in a reduced condition forming a waist (Pedipalpi, Araneæ, Palpigradi) or as a full-sized tergal plate (Pseudo-scorpiones); in some it is entirely atrophied (Solifugæ, Holosomata, and Rhynchostomi). Lateral eyes when present diplostichous.

Remarks.—The Epectinate Arachnids do not stand so close to the aquatic ancestors of the Embolobranchia as do the Pectiniferous scorpions. At the same time we are not justified in supposing that the scorpions stand in any way as an intermediate grade between any of the existing Epectinata and the Delobranchia. It is probable that the Pedipalpi, Araneæ, and Podogona have been separately evolved as distinct lines of descent from the ancient aquatic Arachnida. The Holosomata and Rhynchostomi are probably off-shoots from the stem of the Araneæ, and it is not unlikely (in view of the structure of the prosomatic somites of the Tartarides) that the Solifugæ are connected in origin with the Pedipalpi. The appearance of tracheæ in place of lung-sacs cannot be regarded as a starting-point for a new line of descent comprising all the tracheate forms; tracheæ seem to have developed independently in different lines of descent. On the whole, the Epectinata are highly specialized and degenerate forms, though there are few, if any, animals which surpass the spiders in rapidity of movement, deadliness of attack, and constructive instincts.

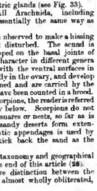


FIG. 53.—The same Scorpion carrying the now paralysed fly held in its chelicerae, the chelæ liberated for attack and defence. Drawn from life. (From Lankester, *Journ. Linn. Soc.*)

Order 2. Pedipalpi (Figures 54 to 59).—Appendages of 1st pair bisegmented, without poison gland; of 2nd pair prehensile, their basal segments underlying the proboscis, and furnished with sterno-coxal (maxillary) process, the apical segment tipped with a single movable or immovable claw; appendages of 3rd pair different from the remainder, tactile in function, with at least the apical segment many-jointed and clawless. The ventral surface of the prosoma bears prosternal, metasternal, and usually mesosternal chitine-plates (Fig. 55). A narrow præ-genital somite is present between opisthosoma and prosoma (Figs. 55, 57). Opisthosoma consisting of eleven somites, almost wholly without visible appendages. Intromittent organ of male beneath the genital operculum (=sternum of the 1st somite of opisthosoma).

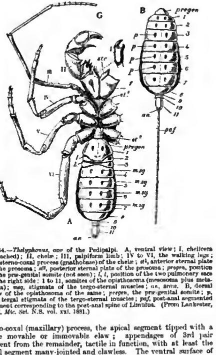


FIG. 54.—*Thelyphonus*, one of the Pedipalpi. A, ventral view; I, chelicera (detached); II, chelæ; III, palpiform limb; IV to VI, the walking legs; *stc*, sterno-coxal process (gnathobase) of the chelæ; *st*¹, anterior sternal plate of the prosoma; *st*², posterior sternal plate of the prosoma; *pregen*, position of the pre-genital somite (not seen); *l*, *l*, position of the two pulmonary sacs of the right side; 1 to 11, somites of the opisthosoma (mesosoma plus metasoma); *msg*, stigmata of the tergo-sternal muscles; *an*, anus. B, dorsal view of the opisthosoma of the same; *pregen*, the pre-genital somite; *p*, the tergal stigmata of the tergo-sternal muscles; *paf*, post-anal segmented filament corresponding to the post-anal spine of Limulus. (From Lankester, *Q. J. Mic. Sci.* N.S. vol. xxi. 1881.)

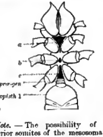


FIG. 55.—*Thelyphonus sp.* Ventral view of the anterior portion of the body to show the three prosomatic sternal plates *a*, *b*, *c*, and the rudimentary sternal element of the pre-genital somite; *opisth* 1, first somite of the opisthosoma. (From a drawing made by Mr. Pickard-Cambridge, under the direction of Mr. R. I. Pocock.)

Note.—The possibility of another interpretation of the anterior somites of the mesosoma and the præ-genital somite must be borne in mind. Possibly, though not probably, the somites carrying the two lung-sacs correspond to the first two lung-bearing somites of Scorpio, and it is the genital opening which has shifted. The same caution applies in the case of the Araneæ. Excalation of one or of two anterior mesosomatic somites, besides the prægenital somite, would then have to be supposed to have occurred also.

Sub-order *a.* Uropygi.—Prosoma longer than wide, its sternal area very narrow, furnished with a large prosternal and metasternal plate, and often with a small mesosternal sclerite. Appendages of 2nd pair with their basal segments united in the middle line and incapable of lateral movement; appendages of 3rd pair with only the apical segment many-jointed. Opisthosoma without trace of appendages; its posterior somites narrowed to form a movable tail for the support of the post-anal sclerite, which has no poison glands.

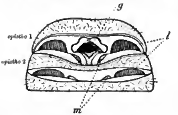


Fig. 56.—*Thelyphonus assamensis* ♂. Ventral surface of the anterior region of the opisthosoma, the first somite being pushed upwards and forwards so as to expose the subjacent structures. *opistho* 1, First somite of the opisthosoma; *opistho* 2, second do.; *g*, genital aperture; *l*, edges of the lamellæ of the lung-books; *m*, stigmata of tergo-sternal muscles. (Original drawing by Mr. Pocock.)

Tribe 1. Urotricha.—Dorsal area of prosoma covered with a single shield (? two in *Geralinura*), bearing median and lateral eyes. Post-anal sclerite modified as a long, many-jointed feeler. Appendages of 2nd pair folding in a horizontal plane, completely chelate, the claw immovably united to the sixth segment. Respiratory organs present in the form of pulmonary sacs.

Family—Thelyphonidæ (*Thelyphonus* (Fig. 54), *Hypoctonus*, **Geralinura*).

Tribe 2. Tartarides.—Small degenerate forms with the dorsal area of the prosoma furnished with two shields, a larger in front covering the anterior four somites, and a smaller behind covering the 5th and 6th somites; the latter generally subdivided into a right and left portion; rarely there is a pair of narrow sclerites interposed between the anterior and posterior shields. Eyes evanescent or absent. Appendages of 2nd pair folding in a vertical plane, not chelate, the claw long and movable. Post-anal sclerite short and undivided. No distinct respiratory stigmata behind the sterna of the 1st and 2nd somites of the opisthosoma.

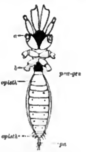


Fig. 57.—*Schizomus crassicaudatus*, one of the Tartarid Pedipalpi. Ventral view of a female with the appendages cut short near the base. *a*, Prosternum of prosoma; *b*, metasternum of prosoma; *pre-gen*, the pre-genital somite; 1 *opisth*, first somite of the opisthosoma; 11 *opisth*, eleventh somite of the opisthosoma; *pa*, post anal lobe of the female (compare the jointed filament in *Thelyphonus*, Fig. 54). (Original drawing by Mr. Pickard Cambridge, directed by Mr. Pocock.)

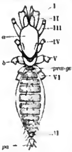


Fig. 58.—*Schizomus crassicaudatus*, a Tartarid Pedipalp. Dorsal view of a male with the appendages cut short. I to VI, the prosomatic appendages; *a*, anterior plate, and *b*, posterior plate of the prosomatic carapace; *pre-gen*, tergum of the pre-genital somite; 11, the eleventh somite of the opisthosoma; *pa*, post-anal lobe of the male—a conical body with narrow basal stalk. (Original as above.)

Family—Hubbardiidæ (*Schizomus*, *Hubbardia*) (Figs. 57-59).

Sub-order *b.* Amblypygi.—Prosoma wider than long, covered above by a single shield bearing median and lateral eyes, which have diplostichous ommatea. Sternal area broad, with prosternal, two mesosternal, and metasternal plates, the prosternum projecting forwards beneath the coxæ of the 2nd pair of appendages. Appendages of 2nd pair folding in a horizontal plane; their basal segments freely movable; claw free or fused; basal segments of 4th and 5th pairs widely separated by the sternal area; appendages of 3rd pair with all the segments except the proximal three, forming a many-jointed flagellum. Opisthosoma without post-anal sclerite and posterior caudal elongation: with frequently a pair of small lobate appendages on the sternum of the 3rd somite. Respiratory organs, as in Urotricha.

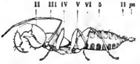


Fig. 59.—*Schizomus crassicaudatus*, one of the Pedipalpi. Lateral view of a male. II to VI, the prosomatic appendages, the first being concealed (see Fig. 58); 5, the fifth, and 11, the eleventh tergites of the opisthosoma; *pa*, the conical post-anal lobe. (Original as above.)

Family—Phrynichidæ (*Phrynichus*, *Damon*).
 „ Admetidæ (*Admetus*, *Heterophrynus*).
 „ Charontidæ (*Charon*, *Sarax*).
(Family ?)—*Geraphrynus.

Remarks.—The Pedipalpi are confined to the tropics and warmer temperate regions of both hemispheres. Fossil forms occur in the Carboniferous. The small forms known as *Schizomus* and *Hubbardia* are of special interest from a morphological point of view. The Pedipalpi have no poison glands. (Reference to literature (29).)

Order 3. Araneæ (Figs. 60 to 64).—Prosoma covered with a single shield and typically furnished with median and lateral eyes of diplostichous structure, as in the Amblypygi. Its sternal surface wide, continuously chitinized, but with prosternal and metasternal elements generally distinguishable at the anterior and posterior ends respectively of the large mesosternum. Presternum underlying the proboscis. Appendages of 1st pair have two segments, as in Pedipalpi, but are furnished with poison gland, and are retroverts. Appendages of 2nd pair not underlying the mouth, but freely movable and, except in primitive forms, furnished with a maxillary lobe; the rest of the limb like the legs, tipped with a single claw and quite unmodifed (except in ♂).

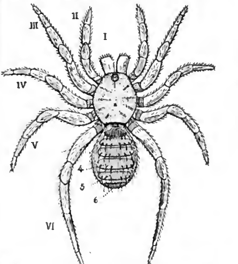


Fig. 60.—*Liphistius desultor*, Schiödte, one of the Araneæ Mesothelæ. Dorsal view. I to VI, the prosomatic appendages; 4, 5, 6, the fourth, fifth, and sixth tergites of the opisthosoma. Between the bases of the sixth pair of limbs and behind the prosomatic carapace is seen the tergite of the small pre-genital somite. (Original by Pickard-Cambridge and Pocock.)

Remaining pairs of appendages similar in form and function, each tipped with two or three claws. Opisthosoma when segmented showing the same number of somites as in the Pedipalpi; usually unsegmented, the pre-genital somite constricted to form the waist; the appendages of its 3rd and 4th somites retained as spinning mammillæ. Respiratory organs (see Fig. 63, *stg*), as in the Amblypygi, or with the posterior pair, rarely the anterior pair as well, replaced by tracheal tubes. Intromittent organ of male in the apical segment of the 2nd prosomatic appendage.

Sub-order *a*. Mesothelæ (see Figs. 60 to 63).—Opisthosoma distinctly segmented, furnished with 11 tergal plates, as in the Amblypygi; the ventral surface of the 1st and 2nd somites with large sternal plates, covering the genital aperture and the two pairs of pulmonary sacs, the sternal plates from the 6th to the 11th somites represented by integumental ridges, weakly chitinized in the middle. The two pairs of spinning appendages retain their primitive position in the middle of the lower surface of the opisthosoma far in advance of the anus on the 3rd and 4th somites, each appendage consisting of a stout, many-jointed outer branch and a slender, unsegmented inner branch. Prosoma as in the Mygalomorphæ, except that the mesosternal area is long and narrow.

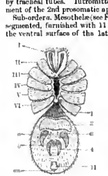


FIG. 61.—*Liphistius desultor.* Ventral view with the prosomatic appendages cut short excepting the chelicerae (I) whose sharp retroverts are seen. Between the bases of the prosomatic limbs an anterior and a posterior sternal plate (black) are seen. 1, the sternum of the first opisthosomatic or genital somite covering the genital aperture and the first pair of lung-sacs. In front of it the narrow waist is formed by the soft sternal area of the pre-genital somite; 2, the sternite of the second opisthosomatic somite covering the posterior pair of lung-sacs; 3 and 4, the spinning appendages (limbs) of the opisthosoma; *a*, inner, *b*, outer ramus of the appendage; 11, sternite of the eleventh somite of the opisthosoma: in front of it other rudimentary sternites; an, anus. (Original as above.)

Family—Liphistiidæ (*Liphistius*, **Arthrolycosa*).

Sub-order *b*. Opisthothelæ (see Fig. 63).—Opisthosoma without trace of separate terga and sterna, the segmentation merely represented posteriorly by slight integumental folds and the sterna of the 1st and 2nd somites by the opercular plates of the pulmonary sacs. The spinning appendages migrate to the posterior end of the opisthosoma and take up a position close to the anus; the inner branches of the anterior pair either atrophy or are represented homogenetically by a plate, the cribellum, or by an undivided membranous lobe, the colulus.

Tribe 1. Mygalomorphæ.—The plane of the articulation of the appendages of the 1st pair to the prosoma (the retrovert) vertical, the basal segment projecting straight forwards at its proximal end, the distal segment or fang closing backwards in a direction subparallel to the long axis of the body. Two pairs of pulmonary sacs.

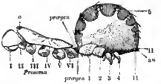


FIG. 62.—*Liphistius desultor.* Lateral view. I to VI, appendages of the prosoma cut off at the base; *o*, ocular tubercle; *progen*, the pre-genital somite; 1 and 2, sternites of the first and second opisthosomatic somites; 3 and 4, appendages of the third and fourth opisthosomatic somites, which are the spinning organs, and in this genus occupy their primitive position instead of migrating to the anal region as in other spiders; 5, tergite of the fifth opisthosomatic somite; 11, eleventh opisthosomatic somite; an, anus. (Original.)

Families—Theraphosidæ (*Avicularia*, *Pœcilotheria*). Barychelidæ (*Barychelus*, *Plagiobothrus*). Dipluridæ (*Diplura*, *Macrothele*). Ctenizidæ (*Cteniza*, *Nemesia*). Atypidæ (*Atypus*, *Calommata*).

Tribe 2. Arachnomorphæ.—The plane of the articulation of the appendages of the 1st pair to the prosoma horizontal, the basal segment projecting vertically downwards, at least at its proximal end, the distal segment or fang closing inwards nearly or quite at right angles to the long axis of the body. The posterior pulmonary sacs (except in *Hypochilus*) replaced by tracheal tubes; the anterior and posterior pairs replaced by tracheal tubes in the Caponiidæ.

Principal families—Hypochilidæ (*Hypochilus*). Dysderidæ (*Dysdera*, *Segestria*). Caponiidæ (*Caponia*, *Nops*). Filistatidæ (*Filistata*). Uloboridæ (*Uloborus*, *Dinopis*). Argiopidæ (*Nephila*, *Gasteracantha*). Pholcidæ (*Pholcus*, *Artema*). Agelenidæ (*Tegenaria*). Lycosidæ (*Lycosa*). Clubionidæ (*Clubiona*, *Olios*, *Sparassus*). Gnaphosidæ (*Gnaphosa*, *Hemiclæa*). Thomisidæ (*Thomisus*). Attidæ (*Salticus*). Urocteidæ (*Uroctea*). Eresidæ (*Eresus*).

Remarks on the Araneæ.—The Spiders are the most numerous and diversified group of the Arachnida; about 2000 species are known. No noteworthy fossil spiders are known; the best preserved are in amber of Oligocene age. *Protolycosa* and *Arthrolycosa* occur in the Carboniferous. Morphologically, the spiders are remarkable for the concentration and specialization of their structure, which is accompanied with high physiological efficiency. The larger species of Bird's Nest Spiders (Avicularia), the opisthosoma of which is as large as a bantam's egg, undoubtedly attack young birds, and M'Cook gives an account of the capture in its web by an ordinary house spider of a small mouse. The "retrovert" or bent-back first pair of appendages is provided with a poison gland opening on the fang or terminal segment. Spiders form at least two kinds of constructions—snares for the capture of prey and nests for the preservation of the young. The latter are only formed by the female, which is a larger and more powerful animal than the male. Like the scorpions the spiders have a special tendency to cannibalism, and accordingly the male, in approaching the female for the purpose of fertilising her, is liable to be fallen upon and sucked dry by the object of his attentions. The sperm is removed by the male from the genital aperture into a special receptacle on the terminal segment of the 2nd prosomatic appendage. Thus held out at some distance from the body, it is cautiously advanced by the male spider to the genital aperture of the female.

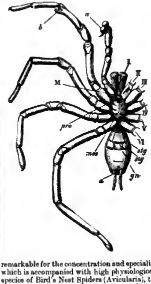


FIG. 63.—Ventral view of a male mygalomorphous Spider. I to VI, the six pairs of prosomatic appendages; *a*, copulatory apparatus of the second appendage; *b*, process of the fifth joint of the third appendage; M, mouth; *pro*, prosternite of the prosoma; *mes*, mesosternite of the prosoma: observe the contact of the coxæ of the sixth pair of limbs behind it: compare Liphistius (Fig. 61) where this does not occur; *stg*, lung aperture; *gn*, genital aperture; *a* anus with a pair of backwardly migrated spinning appendages on each side of it; compare the position of these appendages in Liphistius (Fig. 61.) (From Lankester, "Limulus an Arachnid.")

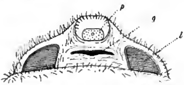


FIG. 64.—*Liphistius desultor.* Under side of the uplifted genital or first opisthosomatic somite of the female; *g*, genital aperture; *p*, pitted plate, probably a gland for the secretion of adhesive material for the eggs; *l*, the edges of the lamellæ of the lung-books of the first pair. (Original drawing by Pocock.)

For an account of the courtship and dancing of spiders, of their webs and floating lines, the reader is referred to the works of M'Cook (**30**) and the Peckhams (**31**), whilst an excellent account of the nests of trap-door spiders is given by Moggridge (**32**). References to systematic works will also be found at the end of this article (**33**).

Order 4. Palpigradi = Microthelyphonida (see Fig. 65).—Prosoma covered above by three plates, a larger representing the dorsal elements of the first four somites, and two smaller representing the dorsal elements of the 5th and 6th.

Its ventral surface provided with one prosternal, two mesosternal, and one metasternal plate. Appendages of 1st pair consisting of three segments, completely chelate, without poison gland; of 2nd pair slender, leg-like, tipped with three claws, the

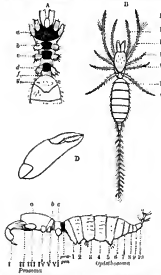


FIG. 65.—*Kœnenia mirabilis*, Grassi, one of the Palpigradi. A, ventral view of prosoma and of anterior region of opisthosome with the appendages cut off near the base; *a* and *b*, prosternites; *c*, mesosternite; and *d*, metasternite of the prosoma; *f*, ventral surface of the præ-genital somite; *g*, sternite of the genital somite (first opisthosomatic somite). B dorsal view. I to VI, prosomatic appendages; 1 *opisth*, genital somite (first opisthosomatic somite). C, lateral view. I to VI, prosomatic appendages; *a*, *b*, *c*, the three tergal plates of the prosoma; *præ gen*, the præ-genital somite; 1 to 10, the ten somites of the opisthosoma. D, chelicera. (Original drawing by Pocock and Pickard-Cambridge, after Hansen and Sorensen.)

basal segment without sterno-coxal process taking no share in mastication, and widely separated from its fellow of the opposite side; 3rd, 4th, 5th, and 6th appendages similar in form to the 2nd and to each other.

Proboscis free, not supported from below by either the prosternum or the basal segments of the appendages of the 2nd pair.

Opisthosoma consisting of only ten somites, which have no tergal and sternal elements, the præ-genital somite contracted to form a "waist," as in the Pedipalpi; the last three narrowed to form a caudal support for the many-jointed flagelliform telson, as in the Urotricha. Respiratory organs atrophied.

Family—Kœneniidæ (*Kœnenia*).

Remarks.—An extremely remarkable minute form originally described by Grassi (**34**) from Sicily, and since further described by Hansen (**35**). Recently the genus has been found in Texas, U.S.A. Only one genus of the order is known.

Order 5. Solifugæ = Mycetophoræ (see Figs. 66 to 69).—Dorsal area of prosoma covered with three distinct plates, two smaller representing the terga of the 5th and 6th somites, and a larger representing those of the anterior four somites, although the reduced terga of the 3rd and 4th are traceable behind the larger plate. The latter bears a pair of median eyes and obsolete lateral eyes on each side. Sternal elements of prosoma almost entirely absent, traces of a prosternum and metasternum alone remaining. Rostrum free, not supported by either the prosternum or the basal segments of the appendages. Appendages of 1st pair large, chelate, bisegmented, articulated to the sides of the head-shield; appendages of 2nd pair simple, pediform, with protrusible (?suctorial) organ, and no claws at the tip; their basal segments united in the middle line and furnished with sterno-coxal process. Remaining pairs of appendages with their basal segments immovably fixed to the sternal surface, similar in form, the posterior three pairs furnished with two claws supported on long stalks; the basal segments of the 6th pair bearing five pairs of tactile sensory organs or malleoli. The præ-genital somite is suppressed. Opisthosoma composed of ten somites. Respiratory organs tracheal, opening upon the ventral surface of the 2nd and 3rd, and sometimes also of the 4th somite of the opisthosoma. A supplementary pair of tracheæ opening behind the basal segment of the 4th appendage of the prosoma.

(? Intromittent organ of male lodged on the dorsal side of the 1st pair of prosomatic appendages.)

Families — Hexisopodidæ (*Hexisopus*). Solpugidæ (*Solpuga*, *Rhagodes*). Galeodidæ (*Galeodes*).

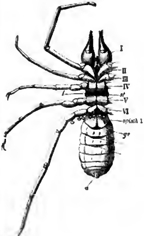


FIG. 66.—*Galeodes*, sp., one of the Solifugæ. Ventral view to show legs and somites. I to VI, the six leg-bearing somites of the prosoma; *opisth* 1, first or genital somite of the opisthosoma; *g°*, site of the genital aperture; *st*, thoracic tracheal aperture; *I²*, anterior tracheal aperture of the opisthosoma in somite 2 of the opisthosoma; *I³*, tracheal aperture in somite 3 of the opisthosoma; *a*, anus. (From Lankester, "Limulus an Arachnid.")

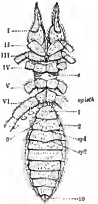


FIG. 67.—*Galeodes*, sp., one of the Solifugæ. Ventral view with the appendages cut off at the base. I to VI, prosomatic appendages; *s*, prosomatic stigma or aperture of the tracheal system; 1, first opisthosomatic sternite covering the genital aperture *g*; 2, second opisthosomatic sternite covering the second pair of tracheal apertures sp1; *sp2*, the third pair of tracheal apertures; 10, the tenth opisthosomatic somite; *an*, the anal aperture. (Original by Pickard-Cambridge and Pocock.)

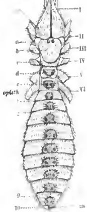


FIG. 68.—*Galeodes*, sp., one of the Solifugæ. Dorsal view. I to VI, bases of the prosomatic appendages; *o*, eyes; *a*, lateral region of the cephalic plate to which the first pair of appendages are articulated; *b*, cephalic plate with median eye; *c*, dorsal element of somites bearing third and fourth pairs of appendages; *d*, second plate of the prosoma with fifth pair of appendages; *e*, third or hindermost plate of the prosoma beneath which the sixth pair of legs is articulated; 1, 2, 9, 10, first, second, ninth, and tenth somites of the opisthosoma; *an*, anus. (Original.)

Remarks.—These most strange-looking Arachnids occur in warmer temperate, and tropical regions of Asia, Africa, and America. Their anatomy has not been studied, as yet, by means of freshly-killed material, and is imperfectly known, though the presence of the coxal glands was determined by Macleod in 1884. The proportionately enormous chelæ (chelicerae) of the first pair of appendages are not provided with poison glands; their bite is not venomous.

Galeodes has been made the means of a comparison between the structure of the Arachnida and Hexapod insects by Haeckel and other writers, and it was at one time suggested that there was a genetic affinity between the two groups—through Galeodes, or extinct forms similar to it. The segmentation of the prosoma and the form of the appendages bear a homoplastic similarity to the head, pro-, meso-, and meta-thorax of a Hexapod with mandibles, maxillary palps and three pairs of walking legs; whilst the opisthosoma agrees in form and number of somites with the abdomen of a Hexapod, and the tracheal stigmata present certain agreements in the two cases. Reference to literature (36).

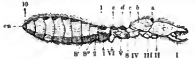


FIG. 69.—*Galeodes*, sp., one of the Solifugæ. I to VI, the six prosomatic limbs cut short; a, the eyes; b, c, demarcated areæ of the cephalic or first prosomatic plate corresponding respectively to appendages I, II, III and to appendage IV (see Fig. 68). *d*, second plate of the prosoma-carrying appendage V; e, third plate of the prosoma-carrying appendage VI. The præ-genital somite is absent. 1, first somite of the opisthosoma; 2, second do.; 8, prosomatic tracheal aperture between legs IV and V; 8′ and 8″, opisthosomatic tracheal apertures; 10, tenth opisthosomatic somite; an, anus. (Original.)

Order 6. Pseudoscorpiones = Chelonethi, also called Chernetidia (see Figs. 70, 71, 72).—Prosoma covered by a single dorsal shield, at most furnished with one or two diplostichous lateral eyes; sternal elements obliterated or almost obliterated. Appendages of the 1st pair bisegmented completely chelate, furnished with peculiar organs, the *serrula* and the *lamina*. Appendages of 2nd pair very large and completely chelate, their basal segments meeting in the middle line, as in the Uropygi, and provided in front with membranous lip-like processes underlying the proboscis. Appendages of the 3rd, 4th, 5th, and 6th pairs similar in form and function, tipped with two claws, their basal segments in contact in the median ventral line. The præ-genital somite wide, not constricted, with large tergal plate, but with its sternal plate small or inconspicuous. Opisthosoma composed, at least in many cases, of eleven somites, the 11th somite very small, often hidden within the 10th. Respiratory organs in the form of tracheal tubes opening by a pair of stigmata in the 2nd and 3rd somites of the opisthosoma. Intromittent organ of male beneath sternum of the 1st somite of the opisthosoma.

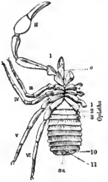


FIG. 70.—*Garypus litoralis*, one of the Pseudoscorpiones. Ventral view, I to VI, prosomatic appendages; o, sterno-coxal process of the basal segment of the second appendage; 1, sternite of the genital or first opisthosomatic somite; the præ-genital somite, though represented by a tergum, has no separate sternal plate; 2 and 3, sternites of the second and third somites of the opisthosoma, each showing a tracheal stigma; 10 and 11, sternites of the tenth and eleventh somites of the opisthosoma; an, anus. (Original by Pocock and Pickard-Cambridge.)

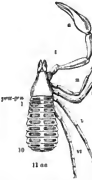


FIG. 71.—*Garypus litoralis*, one of the Pseudoscorpiones. Dorsal view. I to VI, the prosomatic appendages; a, eyes; *præ-gen*, præ-genital somite; 1, tergite of the genital or first opisthosomatic somite; 10, tergite of the tenth somite of the opisthosoma; 11, the evanescent eleventh somite of the opisthosoma; an, anus. (Original.)

Sub-order *a*. Panctenodactyli.—Dorsal plate of prosoma (carapace) narrowed in front; the appendages of the 1st pair small, much narrower, taken together, than the posterior border of the carapace. Serrula on movable digit of appendages of 1st pair fixed throughout its length, and broader at its proximal than at its distal end; the immovable digit with an external process.

Family—Cheliferidæ (*Chelifer* (Figs. 66, 67, 68), *Chiridium*).
" Garypidæ (*Garypus*).

Sub-order *b*. Hemictenodactyli.—Dorsal plate of prosoma scarcely narrowed in front; the appendages of the 1st pair large, not much narrower, taken together, than the posterior border of the carapace. The serrula or the movable digit free at its distal end, narrowed at the base; no external lamina on the immovable digit.

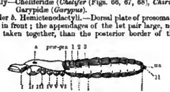


FIG. 72.—*Garypus litoralis*, one of the Pseudoscorpiones. Lateral view. I to VI, basal segments of the six prosomatic appendages; o, eyes; *præ-gen*, tergite of the præ-genital somite; 1, genital or first opisthosomatic somite; 2, 3, 10, the second, third, and tenth somites of the opisthosoma; 11, the minute eleventh somite; an, the anus. (Original.)

Family—Obisiidæ (*Obisium*, *Pseudobisium*).
" Chthoniidæ (*Chthonius*, *Tridenchthonius*).

Remarks.—The Book-scorpions—so called because they were, in old times, found not unfrequently in libraries—are found in rotten wood and under stones. The similarity of the form of their appendages to those of the scorpions suggests that they are a degenerate group derived from the latter, but the large size of the præ-genital somite in them would indicate a connexion with forms preceding the scorpions. Reference to literature (37).

Order 7. Podogona = Meridogastra (see Figs. 73 to 76).—Dorsal area of prosoma furnished with two shields, a larger behind representing, probably, the tergal elements of the somites, and a smaller in front, which is freely articulated to the former and folds over the appendages of the 1st pair. Ventral area without distinct sternal plates. Appendages of 1st pair, tri-segmented, completely chelate. Appendages of 2nd pair, with their basal segments uniting in the middle line below the mouth, weakly chelate at apex. Appendages of 3rd, 4th, 5th, and 6th pairs similar in form; their basal segments in contact in the middle line and immovably welded, except those of the 3rd pair, which have been pushed aside so that the bases of the 2nd and 4th pairs are in contact with each other. A movable membranous joint between the prosoma and the opisthosoma, the generative aperture opening upon the ventral side of the membrane. Præ-genital somite suppressed; the opisthosoma consisting of only four visible somites, in addition to a tubular ring round the anal orifice. Respiratory organs unknown. Intromittent organ of male placed at the distal end of the appendage of the 5th pair.

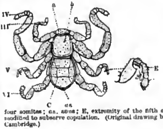


FIG 73.—*Cryptostemma Karschii*, one of the Podogona. Dorsal view of male, enlarged five times linear. III to VI, the third, fourth, fifth, and sixth appendages of the prosoma; a, movable (hinged) sclerite (so-called hood) overhanging the first pair of appendages; b, fused terga of the prosoma followed by the opisthosoma of four somites; an, anus; E, extremity of the fifth appendage of the male modified to subserve copulation. (Original drawing by Pocock and Pickard-Cambridge.)

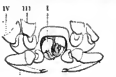


FIG. 74.—*Cryptostemma Karschii*, anterior aspect of the prosoma with the "hood" removed. I to IV, first to fourth appendages of the prosoma; a, basal segment of the second pair of appendages meeting its fellow in the middle line (see Fig. 75). (Original drawing by Pocock and Pickard-Cambridge.)

Family—Cryptostemmidæ (*Cryptostemma*) (**Anthracomartus*) Carboniferous.

Remarks on the Podogona.—The name given to this small but remarkable group has reference to the position of the male intromittent organ (Fig. 73, E). They are small degenerate animals with a relatively firm integument. Not more than four species and twice that number of specimens are known. They have been found in West Africa, and South America. A fact of special interest in regard to them is that the genus Anthracomartus, from the Coal Measures, appears to be a member of the same group. The name Cryptostemma, given to the first-known genus of the order, described by Guérin-Méné-ville, refers to the supposed concealment of the eyes by the movable cephalic sclerite. Reference to literature (36).

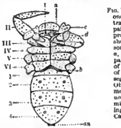


Fig. 75.—*Cryptostemma Karschii*, one of the Podogona. Ventral view. I to VI, the six pairs of appendages of the prosoma, the last three cut short; 1, 2, 3, 4, the four somites of the opisthosoma; *a*, hood overhanging the first pair of appendages; *b*, position of the genital orifice; *c*, part of 3rd appendage; *d*, fourth segment of 2nd appendage. Observe that the basal segment of appendage III does *not* meet its fellow in the middle line. (Original drawing by Pocock and Pickard-Cambridge.)

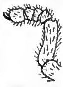


Fig. 76. — *Cryptostemma Karschii.* Extremity of the fifth pair of appendages of the female for comparison with that of the male E in Fig. 73.

Order 8. Opiliones (see Fig. 77).—Dorsal area of prosoma covered by a single shield bearing a pair of median eyes, or one or two pairs of lateral eyes. Sternal elements much reduced. Appendages of 1st pair large, three segmented, and completely chelate; of 2nd pair either simple and pediform, or prehensile and subchelate; of remaining four pairs, similar in form, ambulatory in function. Mouth lying far back, the basal segment of the 2nd, 3rd, and sometimes of the 4th pairs of appendages furnished with sterno-coxal (maxillary) lobe. Opisthosoma confluent throughout its breadth with the prosoma, with the dorsal plate of which its anterior tergal plates are more or less confluent; nine opisthosomatic somites traceable; the generative aperture thrust far forwards between the basal segments of the 6th or 5th and 6th appendages. Præ-genital somite suppressed. Respiratory organs, tracheal opening by a pair of stigmata situated immediately behind the basal segments of the 6th pair of appendages on what is probably the sternum of the 3rd opisthosomatic somite, and also in some cases upon the 5th segment of the legs.

Intromittent organ of male lying within the genital orifice.

Sub-order *a*. Laniatores.—The area between the mouth below and the basal segments of the appendages of the 1st pair above occupied by two unpaired skeletal pieces, the *clypeus* and *labrum*. Sternal area of prosoma occupied by a relatively long and very narrow sclerite, composed of prosternal and metasternal elements, and lying between the coxæ of the appendages of the 5th pair, and interposing between the mouth and generative orifice; the latter lodged between the basal segments of the appendages of the 6th pair. Appendages of 2nd pair strong, generally spiny, and armed with a powerful claw. Appendages of 3rd and 4th pairs armed with a single claw; those of 5th and 6th with two claws. Sterno-coxal process of 3rd pair of appendages coalesced with the basal segment; that of the 4th pair not or scarcely developed.

Principal families—Gonyleptidæ (*Gonyleptes, Goniosoma*).
Biantidæ (*Biantes*).
Epedanidæ (*Epedanus, Acrobunus*).
Assamiidæ (*Assamia, Pygoplus*).
Oncopodidæ (*Oncopus, Pelitaus*).
Cosmetidæ (*Cosmetus*).

Sub-order *b*. Palpatores.—Resembling the Laniatores, but with the sternal area of prosoma very short, the metasternal sclerite represented by a short transverse plate more or less overlapped by the forwardly-projecting sternal element of the opisthosoma that covers the genital orifice and intervenes between the basal segments of the appendages of the 5th and 6th pairs. The genital orifice thus lies far forwards, close behind the mouth and on a level with the space between the basal segments of the appendages of the 5th pair. Appendages of 2nd pair small, weak, in no sense prehensile, unspined, the claw weak or absent; the 3rd-6th pairs of appendages armed with a single claw. Sterno-coxal process of 3rd appendage movably articulated; a similar lobe generally present on basal segment of 4th appendage.

Principal families—Phalangiidæ (*Phalangium, Liobunum*).
Nemastomidæ (*Nemastoma, Ischyropsalis*).
Trogulidæ (*Trogulus, Anelasmocephalus*).

Sub-order *c*. Anepignathi.—Basal segments of appendages of 2nd pair meeting in the middle line across the area that lies between the mouth below and the basal segments of the appendages of the 1st pair above, to the partial or total exclusion of the unpaired skeletal pieces, known as the clypeus and labrum. Genital orifice lying between the basal segments of the appendages of the 6th pair, and separated from the mouth by a relatively long space occupied by the inner extremities of the basal segments of the 3rd, 4th, 5th, and 6th pairs of appendages, the sternal sclerites being evanescent. Appendages of 2nd-6th pairs short and strong, furnished with a single claw.

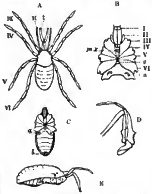


Fig. 77.—*Stylocellus sumatranus*, one of the Opiliones; after Thorell. Enlarged. A, dorsal view; I to VI, the six prosomatic appendages; B, ventral view of the prosoma and of the first somite of the opisthosoma, with the appendages I to VI cut off at the base; *a*, tracheal stigma; *mx*, maxillary processes of the coxæ of the third pair of appendages; *g*, genital aperture. C, ventral surface of the prosoma and opisthosoma; *a*, tracheal stigma; *b*, last somite. D, lateral view of the first and second pair of appendages. E, lateral view of the whole body and two first appendages, showing the fusion of the dorsal elements of the prosoma into a single plate, and of those of the opisthosoma into an imperfectly segmented plate continuous with that of the prosoma.

Family—Cyphophthalmidæ (*Cyphophthalmus, Stylocellus, Petalus*).

Remarks on the Opiliones.—These include the Harvest-men, sometimes called also Daddy-long-legs, with round undivided bodies and very long, easily-detached legs. The intromittent organs of the male are remarkable for their complexity and elaboration. The confluence of the regions of the body and the dislocation of apertures from their typical position are results of degeneration. The Opiliones seem to lead on from the Spiders to the Mites. Reference to literature (39).

Order 9. Rhynchostomi = Acari (see Fig. 78).—Degenerate Arachnids resembling the Opiliones in many structural points, but chiefly distinguishable from them by the following features:—The basal segments of the appendages of the 2nd pair are united in the middle line behind the mouth; those of the 3rd, 4th, 5th, and 6th pairs are widely separated and not provided with sterno-coxal (maxillary) lobes, and take no share in mastication; the respiratory stigmata, when present, belong to the prosoma, and the primitive segmentation of the opisthosoma has entirely or almost entirely disappeared.

Sub-order *a*. *Cryptostigmata*.—Integument hard, strengthened by a continuously chitinized dorsal and ventral sclerite. Tracheæ typically opening by stigmata situated in the articular sockets (acetabula) of the 3rd, 4th, 5th, and 6th pairs of appendages.

Family—Oribatidæ (*Oribata, Nothrus, Hoplophora*).

Sub-order *b*. *Metastigmata*.—Integument mostly like that of the Cryptostigmata. Tracheæ opening by a pair of stigmata situated above and behind the base of the 4th or 5th or 6th pair of appendages.

Families—Gamasidæ (*Gamasus, Pteroptus*).
Argasidæ (*Argas, Ornithodoros*).
Ixodidæ (*Ixodes, Rhipicephalus*).

Sub-order *c*. *Prostigmata*.—Integument soft, strengthened by special sclerites, those on the ventral surface of the prosoma apparently representing the basal segments of the legs embedded in the skin. Tracheæ, except in the aquatic species in which they are atrophied, opening by a pair of stigmata situated close to or above the base of the appendages of the 1st pair (mandibles).

Families—Trombidiidæ (*Trombidium, Tetranychus*).
Hydrachnidæ (*Hydrachna, Atax*).
Halacaridæ (*Halacarus, Leptognathus*).
Bdellidæ (*Bdella, Eupodes*).

Sub-order *d*. *Astigmata*.—Degenerate, mostly parasitic forms approaching the Prostigmata in the development of integumental sclerites and the softness of the skin, but with the respiratory system absent.

Families—Tyroglyphidæ (*Tyroglyphus, Rhizoglyphus*).
Sarcoptidæ (*Sarcoptes, Analges*).

Sub-order *e*. *Vermiformia*.—Degenerate atracheate parasitic forms with the body produced posteriorly into an annulated caudal prolongation, and the 3rd, 4th, 5th, and 8th pairs of appendages short and only three-jointed.

Family—Demodicidæ (*Demodex*).

Sub-order *f. Tetrapoda.*—Degenerate atracheate gall-mites, in which the body is produced posteriorly and annulated, as in *Demodex*, but in which the appendages of the 3rd and 4th pairs are long and normally segmented, and those of the 5th and 6th pairs entirely absent.

Family—Eriophyidæ (*Eriophyes, Phyllocoptes*).

Remarks on the Rhynchostomi.—The Acari include a number of forms which are of importance and special interest on account of their parasitic habits. The ticks (Ixodes) are not only injurious as blood-suckers, but are now credited with carrying the germs of Texas cattle-fever, just as mosquitoes carry those of malaria. The itch-insect (*Sarcoptes scabiei*) is a well-known human parasite, so minute that it was not discovered until the end of the 18th century, and "the itch" was treated medicinally as a rash. The female burrows in the epidermis much as the female Trap-door Spider burrows in turf in order to make a nest in which to rear her young. The male does not burrow, but wanders freely on the surface of the skin. *Demodex folliculorum* is also a common parasite of the sebaceous glands of the skin of the face in man, and is frequent in the skin of the dog. Many Acari are parasitic on marine and freshwater molluscs, and others are found on the feathers of birds and the hair of mammals. Others have a special faculty of consuming dry, powdery vegetable and animal refuse, and are liable to multiply in manufactured products of this nature, such as mouldy cheese. A species of Acarus is recorded as infesting a store of powdered strychnine and feeding on that drug, so poisonous to larger organisms. Reference to literature (**40**).

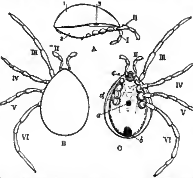


FIG. 78.—*Holothyrus attidissimus*, one of the Acari: after Thorell. Enlarged fifteen times linear. A, lateral view with appendages III to VI removed; 1, plate covering the whole dorsal area, representing the fused tergal sclerites of the prosoma and opisthosoma; 2, similarly-formed ventral plate; 3, tracheal stigma. B, dorsal view of the same animal; II to VI, second to sixth pairs of appendages. The first pair of appendages both in this and in C are retracted. C, ventral view of the same; II to VI as in B; *a*, genital orifice; *b*, anus; *c*, united basal segments of the second pair of appendages; *d*, basal segment of the sixth prosomatic appendage of the right side. The rest of the appendage, as also of app. III, IV, and V, has been cut away. (Original drawing by Pocock and Pickard-Cambridge.)

AUTHORITIES cited by numbers in the text.—**1.** STRAUS-DURKHEIM (as reported by MM. Riester and Sanson in an appendix to the sixth volume of the French translation of Meckel's *Anatomy*, 1829).—**2.** LANKESTER. "Limulus an Arachnid," *Quart. Journ. Micr. Sci.* vol. xxi. N.S. 1881.—**3.** *Idem.* "On the Skeletotrophic Tissues of Limulus, Scorpio, and Mygale," *Quart. Journ. Micr. Sci.* vol. xxiv. N.S. 1884.—**4.** *Idem. Trans. Zool. Soc.* vol. xi. 1883.—**5.** LANKESTER and BOURNE. "Eyes of Limulus and Scorpio," *Quart. Journ. Micr. Sci.* vol. xxiii. N.S. Jan. 1883.—**6.** MILNE-EDWARDS, A. "Recherches sur l'anatomie des Limules," *Ann. Sci. Nat.* 5th series, *Zoologie*, vol. xvii. 1873.—**7.** OWEN, RICHARD. "Anatomy of the King-Crab," *Trans. Linn. Soc. Lond.* vol. xxviii. 1872.—**8.** KISHINOUYE. "Development of *Limulus longispina*," *Journal of the Science College of Japan*, vol. v. 1892.—**9.** BRAUER. "Development of Scorpion," *Zeitschrift für wiss. Zoologie*, vol. lix. 1895.—**10.** HANSEN. "Organs and Characters in Different Orders of Arachnida," *Entomol. Meddel.* vol. iv. pp. 137-149.—**11.** WATASE. "On the Morphology of the Compound Eyes of Arthropods," *Studies from the Biolog. Lab. Johns Hopkins University*, vol. iv. pp. 287-334.—**12.** NEWPORT, GEORGE. "Nervous and Circulatory Systems in Myriapoda and Macrourous Arachnida," *Phil. Trans. Roy. Soc.* 1843.—**13.** LANKESTER. "Coxal Glands of Limulus, Scorpio, and Mygale," *Quart. Journ. Micr. Sci.* vol. xxiv. N.S. 1884.—**13A.** PATTEN and HAZEN. "Development of the Coxal Glands of Limulus," *Journ. of Morphology*, vol. xvi. 1900.—**13B.** BERNARD. "Coxal Glands of Scorpio," *Ann. and Mag. Nat. Hist.* vol. xii. 1893, p. 55.—**14.** BENHAM. "Testis of Limulus," *Trans. Linn. Soc.* 1882.—**15.** LANKESTER. "Mobility of the Spermatozoa of Limulus," *Quart. Journ. Micr. Sci.* vol. xviii. N.S. 1878.—**16.** KORSCHELT and HEIDER. *Entwickelungsgeschichte.* Jena, 1892. *Ibique citata.*—**17.** LAURIE. "The Embryology of a Scorpion," *Quart. Journ. Micr. Sci.* vol. xxxi. N.S. 1890, and "On Development of *Scorpio fulvipes*," *ibid.* vol. xxxii. 1891.—**18.** LANKESTER (Homoplasy and Homogeny). "On the Use of the term Homology in Modern Zoology," *Ann. and Mag. Nat. Hist.* 1870.—**19.** *Idem.* "Degeneration, a Chapter in Darwinism," 1878, reprinted in the *Advancement of Science*, Macmillan, 1890.—**20.** *Idem.* "Limulus an Arachnid," *Q. J. Micr. Sci.* vol. xxi. N.S.—**21.** CLAUS. "Degeneration of the Acari and Classification of Arthropoda," *Anzeiger d. k. k. Akad. Wissen. Wien.* 1885; see also *Ann. and Mag. Nat. Hist.* (5) vol. xvii. 1886, p. 364, and vol. xix. p. 225.—**22.** LINDSTRÖM, G. "Researches on the Visual Organs of the Trilobites," *K. Svenska Vet. Akad. Handl.* xxxiv. No. 8, pp. 1-86, Pls. i.-vi. 1901.—**22*.** ZITTEL. American edition of his *Palæontology* (the Macmillan Co., New York), where ample references to the literature of Trilobitæ and Euryptini will be found; also references to literature of fossil Scorpions and Spiders.—**23.** HOEK. "Report on the Pycnogonida," *Challenger Expedition Reports*, 1881.—MEINERT. "Pycnogonida of the Danish Ingolf Expedition," vol. iii. 1899.—MORGAN. "Embryology and Phylogeny of the Pycnogonids," *Biol. Lab. Baltimore*, vol. v. 1891.—**24.** BOURNE, A. G. "The Reputed Suicide of the Scorpion," *Proc. Roy. Soc.* vol. xlii. pp. 17-22.—**25.** LANKESTER. "Notes on some Habits of Scorpions," *Journ. Linn. Soc. Zool.* vol. xvi. p. 455, 1882.—**26.** HUXLEY. "Pharynx of Scorpion," *Quart. Journ. Micr. Sci.* vol. viii. (old series) 1860, p. 250.—**27.** POCOCK. "How and Why Scorpions hiss," *Natural Science*, vol. ix. 1896. *Cf. idem.* "Stridulating Organs of Spiders," *Ann. and Mag. Nat. Hist.* (6), xvi. pp. 230-233.—**28.** KRAEPOLIN. *Das Thierreich* (*Scorpiones et Pedipalpi*), Berlin, 1899.—PETERS. "Eine neue Eintheilung der Skorpione," *Mon. Akad. Wiss. Berlin*, 1861.—POCOCK. "Classification of Scorpions," *Ann. and Mag. Nat. Hist.* (6) xii. 1893.—THORELL and LINDSTRÖM. "On a Silurian Scorpion," *Kongl. Svens. Vet. Akad. Handl.* xxi. No. 9, 1885.—**29.** CAMBRIDGE, O. P. "A New Family (Tartarides) and Genus of Thelyphonidea," *Ann. and Mag. Nat. Hist.* (4) x. 1872, p. 413.—COOK. "Hubbardia, a New Genus of Pedipalpi," *Proc. Entom. Soc. Washington*, vol. iv. 1899.—KRAEPOLIN. *Das Thierreich.* Berlin, 1899.—THORELL. "Tartarides, &c." *Ann. Mus. Genova*, vol. xxvii. 1889.—**30.** M'COOK. *American Spiders and their Spinning Work*, 3 vols. Philadelphia, 1889-93.—**31.** PECKHAM. "On Sexual Selection in Spiders," *Occasional Papers Nat. Hist. Soc. Wisconsin*, vol. i. pp. 1-113, 1889.—**32.** MOGGRIDGE. *Hunting Ants and Trap-Door Spiders*, 1873.—**33.** BERTKAU. *Arch. f. Naturgesch.* vol. xlviii. pp. 316-62.—*Idem.* Same journal, 1875, p. 235, and 1878, p. 351.—CAMBRIDGE, O. P. "Araneidea" in *Biologia Centr. Americana*, vols. i. and ii. London, 1899.—KEYSERLING. *Spinnen Amerikas.* Nurnberg, 1880-92.—POCOCK. "Liphistius and the Classification of Spiders," *Ann. and Mag. Nat. Hist.* (6) x. 1892.—SIMON. *Hist. nat. des Araignées*, vols. i. and ii. 1892, 1897.—WAGNER. "L'industrie des Araneina," *Mém. Acad. St. Pétersbourg.*—*Idem.* "La mue des Araignées," *Ann. Sci. Nat.* vol. vi.—**34.** GRASSI. "Intorno ad un nuovo Aracnide artrogastro (*Kœnenia mirabilis*), &c." *Boll. Soc. Ent. Ital.* vol. xviii. 1886.—**35.** HANSEN and SORENSEN. "The Order Palpigradi, Thorell (*Kœnenia*), and its Relationships with other Arachnida," *Ent. Tidskr.* vol. xviii. pp. 233-240, 1898.—KRAEPOLIN. *Das Thierreich.* Berlin, 1901.—**36.** BERNARD. "Compar. Morphol. of the Galeodidæ," *Trans. Linn. Soc. Zool.* vol. vi. 1896, *ibique citata.*—DUFOUR. "Galeodes," *Mém. prés. Acad. Sci. Paris*, vol. xvii. 1862.—KRAEPOLIN. *Das Thierreich.* Berlin, 1901.—POCOCK. "Taxonomy of Solifugæ," *Ann. and Mag. Nat. Hist.* vol. xx.—**37.** BALZAN. "Voyage au Venezuela (Pseudoscorpiones)," *Ann. Soc. Entom. France*, 1891, pp. 497-522.—**38.** GUERIN-MENEVILLE. *Rev. Zool.* 1838, p. 11.—KARSCH. "Ueber Cryptostemma Guer." *Berliner Entom. Zeitschrift*, xxxviii. pp. 25-32, 1892.—THORELL. "On an apparently new Arachnid belonging to the family *Cryptostemmidæ*, Westw. *Bihang Svenska Vet. Akad. Handlingar*, vol. xvii. No. 9, 1892.—**39.** SÖRENSEN. "*Opiliones laniatores*," *Nat. Tidskr.* (3) vol. xiv. 1884.—THORELL. "Opilioni," *Ann. Mus. Genova*, vol. viii. 1876.—**40.** BERLESE. "Acari, &c., in Italia reperti." Padova, 1892.—CANESTRINI. *Acarofauna Italiana.* Padova, 1885.—CANESTRINI and KRAMER. "Demodicidæ and Sarcoptidæ" in *Das Thierreich.* Berlin, 1899.—MICHAEL. "British Oribatidæ," *Ray Soc.*—*Idem.* "Oribatidæ" in *Das Thierreich.* Berlin, 1898.—*Idem.* "Progress and Present State of Knowledge of Acari," *Journ. Roy. Micr. Soc.* 1894.—NALEPA. "Phytoptidæ," *Das Thierreich.* Berlin, 1898.—TROUESSART.

"Classification des Acariens," *Rev. Sci. Nat. de l'ouest*, p. 289, 1892.—Wagner. *Embryonal Entwick. von Ixodes.* St. Petersburg, 1893.—41. Bertkau. "Coxaldrusen der Arachniden," *Sitzb. Niederl. Gesellsch.* 1885.—42. Patten. "Brain and Sense Organs of Limulus," *Quart. Journ. Mic. Sci.* vol. xxxv. 1894: see also his "Origin of Vertebrates from Arachnids," *ibid.* vol. xxxi.

Authorities not cited by numbers in the text:—

Lung books.—Berteaux. "Le poumon des Arachnides," *La Cellule*, vol. v. 1891.—Jawarowski. "Die Entwick. d. sogen. Lunge bei der Arachniden," *Zeitsch. wiss. Zool.* vol. lviii. 1894.—Macleod. "Recherches sur la structure et la signification de l'appareil respiratoire des Arachnides," *Arch. Biologie*, vol. v. 1884.—Schneider, A. "Mélanges Arachnologiques," in *Tablettes Zoologiques*, vol. ii. p. 135, 1892.—Simmons. "Development of Lung in Spiders," *Amer. Journ. Science*, vol. xlviii. 1894. **Coxal glands**:—Bertkau. "Ueber die Coxaldrusen der Arachniden," *Sitzb. d. Niederl. Gesellsch.* 1885.—Loman. "Altes und neues über das Nephridium (die Coxaldrüse) der Arachniden," *Bijd. tot de Dierkunde*, vol. xiv. 1887.—Macleod. "Glande coxale chez les Galeodes," *Bull. Acad. Belg.* (3) vol. viii. 1884.—Pelseneer. "On the Coxal Glands of Mygale," *Proc. Zool. Soc.* 1885.—Tower. "The External Opening of the brick-red Glands of Limulus," *Zool. Anzeiger*, vol. xviii. p. 471, 1895. **Entosternite**:—Schimkewitsch. "Bau und Entwick. des Endosternites der Arachniden," *Zool. Jahrb. Anat. Abtheil.* vol. viii. 1894. **Embryology**:—Balfour. "Development of the Araneina," *Q. J. Micr. Sci.* vol. xx. 1880.—Kingsley. "The Embryology of Limulus," *Journ. Morphology*, vols. vii. and viii.—Kishinouye. "Development of Araneina," *Journ. Coll. Sci. Univ. of Japan*, vol. iv. 1890.—Locy. "Development of Agelena," *Bull. Mus. Harvard*, vol. xii. 1885.—Metschnikoff. "Embryologie d. Scorpion," *Zeit. wiss. Zool.* vol. xxi. 1871.—*Idem.* "Embryol. Chelifer," *Zeit. wiss. Zool.* vol. xxi. 1871.—Schimkewitsch. "Développement des Araignées," *Archives d. Biologie*, vol. vi. 1887. **Sense organs**:—Bertkau. "Sinnesorgane der Spinnen," *Arch. f. mikros. Anat.* vol. xxvii. p. 589, 1886.—Graber. "Unicorneale Tracheaten Auge," *Arch. f. mikr. Anat.* vol. xvii. 1879.—Grenacher. *Gehörorgane der Arthropoden.* Gottingen, 1879. Kishinouye. "Lateral Eyes of Spiders." *Zool. Anz.* vol. xiv. p. 381, 1891.—Purcell. "Phalangiden Augen," *Zool. Anzeiger*, vol. xv. p. 461.

General works on Arachnida:—Blanchard. "Les Arachnides" in *L'organisation du règne animal.*—Gaubert. "Recherches sur les Arachnides." *Ann. Sci. Nat.* (7) vol. xiii. 1892.—Koch, C. *Die Arachniden*, 16 vols. Nurnberg, 1831 to 1848.—Koch, Keyserling, and Sorensen. *Die Arachniden Australien.* Nurnberg, 1871-90.—Pocock. *Arachnida of British India.* London, 1900.—*Idem.* "On African Arachnida," in *Proc. Zool. Soc.* and *Ann. and Mag. Nat. Hist.* 1897-1900.—Simon. *Les Arachnides de la France*, 7 vols. Paris, 1874-81.—Thorell. "Arachnida from the Oriental Region," *Ann. Mus. Genova*, 1877-99.

(E. R. L.)

Arad, Old, a municipal town of Hungary, on the river Maros, 145 miles S.E. of Budapest; capital of the county of Arad; a well-equipped modern town, with a considerable trade, including a large distillery. After the surrender of Görgey at Világos, the thirteen captured Hungarian generals were here put to death. A statue of liberty has been erected to their memory, and the anniversary of their death is annually celebrated with great solemnities. There is a museum composed of relics of the war of national independence of 1848-49. Population in 1901, 55,987; of the neighbouring village of New Arad, 6044.

Araguay, River. See Amazon.

Arakan.—This division of Lower Burma on the eastern seaboard of the Bay of Bengal continues to be divided into four districts—Akyab, Northern Arakan Hill Tracts, Sandoway, and Kyaukpyu, which name has been substituted for the older Ramri. Its area is 18,540 square miles, and the population in 1891 was 673,190. The population at the time of its annexation in 1826 did not exceed 100,000. In 1898-99 there were 4014 villages, and the revenue paid was Rs.23,83,406. Akyab remains the only town of importance in the division. Of the 11,865,600 acres in the division, 6,207,270 acres are not capable of cultivation, and in 1898-99 only 800,720 acres were cultivated. The great proportion of the cultivable but not cultivated area was in the Northern Arakan Hill Tracts district, which is under a superintendent, who is usually a police officer with headquarters at Paletwa. The area of the Hill Tracts is 5233 square miles, with a population in 1891 of 14,627, and containing 317 villages. Of the population 13,039 were aborigines—mostly Chins, 1204 were Buddhists and Jains, 366 were Hindus, and 18 were Mahommedans. Only 10,451 acres were cultivated out of the total area of 3,349,120 acres. The rainfall at Paletwa in 1898-99 was 123·91 inches. Sixty-five police maintain order in the district.

Aral (Khvarezm, Aral-denghiz), a large lake of Central Asia, situated to the E. of the Caspian Sea, between 43° 41′ to 46° 45′ N. lat., and 58° 19′ to 61° 47′ E. long., and by its area the second inland salt sea of the world. It covers 26,166 square miles, and has nearly the same length as width, namely, about 170 miles, if its northern gulf (Kichkine-Denghiz) be left out of account. Its depth is insignificant, attaining 222 feet only in a depression in the north-west, and 90 feet in the middle, so that notwithstanding its wide area it contains only eleven times as much water as Lake Leman. Its altitude is 246 feet above the Caspian (Tillo), *i.e.*, about 160 feet above the ocean.

There is no doubt that in recent historical times Lake Aral had a much greater extension than it has now, and that its present area is diminishing at a rapid rate. From a map of 1741 it appears that its north-eastern gulf, Sary-chaganak, protruded about 53 miles farther than it does now, and this is confirmed by what Meyendorff heard in 1820 from the Kirghiz, namely, that, forty years before, the lake reached some hills which are now 40 miles from the shore. Moreover, the large Aibughir Gulf on the southern shore, which was full of water in 1858, is now quite dry, and the Laudan, the most western branch of the Amu, which entered this gulf in 1848 and 1859, has quite dried up since. The salinity of its water is much less than that of the ocean, containing only 0·012 of salt (only 0·006 of chloride of sodium), and the lake freezes every year for a great distance from its shores. The opinion that Lake Aral periodically disappeared, which was for a long time countenanced by Western geographers, loses more and more of its probability now that it becomes evident that at a relatively recent period the Caspian Sea extended much farther eastward than it does now, and that Lake Aral communicated with it through the Sary-Kamysh depression. The present writer is even inclined to think that besides this southern communication with the Caspian, Lake Aral may have been, even in historical times, connected with the Mortvyi Kultuk Gulf of the Caspian, discharging part of its water into that sea, through a depression of the Ust-Urt plateau, which is marked by a chain of lakes (Chumyshty, Asmantai, &c.). In this case it might have been easily confounded with a gulf of the Caspian (by Jenkinson). That the level of Lake Aral was much higher in post-Pliocene times is proved by the finding of shells of their characteristic species of *Pecten* and *Mytilus* in the Kara-kum, 33 miles from the lake at an altitude of 70 feet above its present level, and perhaps even up to 200 feet (by Syevertsoff; see Mushketoff's *Turkestan*). The fishes of Lake Aral belong to fresh-water species, and in some of its rapid tributaries the interesting *Scaphirhynchus*, which represents a survival from the Tertiary epoch, is found. The fishing is very productive, and about 1000 tons of fish are exported yearly to Turkestan, Merv, and even Russia. The shores of the lake are uninhabited, and the nearest settlements are Kazalinsk (7000 inhabitants), 35 miles east, on the Syr, and Chimbai and Kungrad in the delta of the Amu.

Authorities.—The modern works are: Maksheeff's "Description of Lake Aral," and Kaulbars' "Delta of the Amu," in *Zapiski of Russ. Geogr. Soc.*, 1st series, v., and new series, ix.—Grimm's *Studies of the Aral-Caspian Expedition.*—Nikolsky's "Fishing in Lake Aral," in *Izvestia, Russ. Geogr. Soc.*, 1887.—Prof. Mushketoff, *Turkestan*, vol. i. 1886, which contains rich bibliographical indications.

(P. A. K.)

Aral-Caspian Region (or Depression) is the name which is given by geographers to the lowlands in the east of the Caspian Sea, and, by extension, to all the territory comprised between the Lower Volga, the Aral-Irtysh water-parting, the Dzungarian Alatau, and the Hindu Kush. These were also the limits given to it in an excellent work on the geo-botany of this region by the Russian botanist, Borschoff. (See Transcaspian Territory.) Owing to its special geological structure and vegetation, the general aspect of its steppes, exposed to the powerful disintegrating agency of the wind, and its sandy deserts alternating with prairies and oases (see Kara-kum), it represents a distinct geographical type. Large areas are covered with the characteristic Aral-Caspian deposits, which spread as a thin layer, attaining a maximum thickness of 90 feet, but are very much destroyed by the rivers, which have often changed their courses in recent times, and by the winds, which freely blow over this flat, open territory. They attain their fullest development in the part of the Aral-Caspian region which lies to the east of the Caspian Sea, and consist nearly always of a yellow-grayish clay, occasionally taking the character of a more or less compact sandstone of the same colour. Their typical fossils are shells of species still living in both the Caspian and the Aral, but in the shallow parts of them only; namely, according to Mushketoff, *Cardium edule*, L., *Dreyssena polymorpha*; V. Bened., *Neritina liturata*, Eichw., *Adacna vitrea*, Eichw., *Hydrobia stagnalis*, L., in the Kara-kum; and *Lithoglyphus caspius*, Krynitz., *Hydrobia stagnalis*, *Anodonta ponderosa*, Pfr., and the sponge, *Metschnikowia tuberculata*, Grimm, in the Kyzyl-kum. All these are inhabitants of the littoral zone, and only the *Lithoglyphus caspius* is found at greater depths, not exceeding, however, 100 fathoms in the Caspian Sea. The exact limits of the great Aral-Caspian Post-Pliocene Sea are not yet settled, except in the north-west, where the Ergheni hills of the Kalmyk steppe are a distinct barrier. As to its northern limits, the same Aral-Caspian deposits are known to exist 80 miles, but not more than from 130 to 200 miles, north of Lake Aral. They quite certainly do not cross the Aral-Irtysh water-parting. Their eastern limit lies some 100 miles from Lake Aral, but Severtsoff maintained that they extend also into the drainage area of Lake Balkhash (*q.v.*). In the south the same deposits, containing the same species of *Cardium*, *Dreyssena*, *Neritina*, and *Hydrobia*, are known to spread without interruption, 160 miles from Lake Aral, as far as the Bala-ishem wells, in the Sary-kamysh depression (whose surface is below the level of the Caspian), and up the Uzboi for 100 miles from the Caspian. As to their exact extension up the Amu and the Syr, it is not yet known. It is thus concluded that the Aral-Caspian basin had, in Post-Pliocene times, a very wide extension, but that it contained very large islands—Ust-Urt, &c.—which divided it into several parts, its eastern portion communicating with the western, but by one or two narrow straits. These channels, which were formerly taken for old beds of the Amu-daria, have only dried up at a recent epoch, and most probably they existed in historical times.

See Mushketoff's *Turkestan*, St Petersburg, 1886, where all indications of literature are given. (P. A. K.)

Aran Islands, South; three islands—Inishmore, Inishmaan, and Inisheer—lying across Galway Bay on the W. coast of Ireland. The Congested Districts Board has of recent years made efforts to improve the condition of the inhabitants, especially by introducing better methods of fishing. A curing station has been established at Killeany. Population about 3000.

Ararat, (1) Assyrian *Urardhu*, the country in which the Ark rested after the Deluge (Gen. viii. 4), and to which the murderers of Sennacherib fled (2 Kings xix. 37; Isaiah xxxvii. 38). The name Urardhu, originally that of a principality which included Mount Ararat and the plain of the Araxes, is given in Assyrian inscriptions from the 9th century B.C. downwards to a kingdom that at one time included the greater part of the later Armenia. The native name of the kingdom was *Biainas*, and its capital was *Dhuspas*, now Van. The first king, Sarduris I. (*circ.* 833 B.C.), subdued the country of the Upper Euphrates and Tigris. His inscriptions are written in cuneiform, in Assyrian, whilst those of his successors are in cuneiform, in their own language, which is neither Aryan nor Semitic. The kings of Biainas extended their kingdom eastward and westward, and defeated the Assyrians and Hittites. But Sarduris II. was overthrown by Tiglath Pileser II. (743 B.C.), and driven north of the Araxes, where he built Armavir, *Armauria*. Interesting specimens of Biainian art have been found on the site of the palace of Rusas II., near Van. Shortly after 645 B.C. the kingdom fell, possibly conquered by Cyaxares, and a way was thus opened for the immigration of the Aryan Armenians. The name Ararat is unknown to the Armenians of the present day. The limits of the Biblical Ararat are not known, but they must have included the lofty Armenian plateau which overlooks the plain of the Araxes on the north, and that of Mesopotamia on the south. It is only natural that the highest and most striking mountain in the district should have been regarded as that upon which the Ark rested, and that the old name of the country should have been transferred to it. According to the Babylonian account of the Deluge, the resting-place of the Ark was "on the mountain of Nizir," which some writers have identified with Mount Rowanduz, and others with Mount Elburz, near Tehrán. The Kúrds, Syrians, and Nestorians regard Jebel Judi, on the left bank of the Tigris, near Jezíre, as the mountain.

Sayce, "Cuneiform Inscriptions of Lake Van," in *Journal of Royal Asiatic Society*, vols. xiv., xx., and xxvi.—Maspero, *Histoire ancienne des peuples de l'Orient classique*, tom. iii. *Les Empires*, Paris, 1899.—Articles, "Ararat," in Smith's *Dictionary of the Bible*, Hastings' *Dictionary of the Bible*, and *Encyclopædia Biblica*.

(2) Ararat, Armenian *Massis*, Turkish *Egri Dagh*, "Painful Mountain," Persian, *Koh-i-Nuh*, "Mountain of Noah," is the name given to the culminating point of the Armenian plateau which rises to a height of 17,100 feet above the sea. The *massif* of Ararat rises on the north and east out of the alluvial plain of the Araxes, here from 2500 feet to 3000 feet above the sea, and on the south-west sinks into the plateau of Bayezid, about 4500 feet. It is thus isolated on all sides but the north-west, where a *col* about 6900 feet high connects it with a long ridge of volcanic mountains. Out of the *massif* rise two peaks, "their bases confluent at a height of 8800 feet, their summits about 7 miles apart." The higher, Great Ararat, is "a huge broad-shouldered mass, more of a dome than a cone"; the lower, Little Ararat, 12,840 feet, on which the territories of the Tsar, the Sultan, and the Shah meet, is "an elegant cone or pyramid, rising with steep, smooth, regular sides into a comparatively sharp peak" (Bryce). Both peaks are entirely composed of igneous rock, but all eruptive activity has long ceased. On the north and west the slopes of Great Ararat are covered with glittering fields of unbroken *névé*. The only true glacier is on the north-east side, at the bottom of a large chasm which runs into the heart of the mountain. The great height of the snow-line, 14,000 feet, compared with the average of the Alps, 8500-9000 feet, is due to the small rainfall and the upward rush of dry air from the plain of the Araxes. The middle zone of Ararat, 5000-

11,500 feet, is covered with good pasture; the upper and lower zones are for the most part sterile. Many traditions connected with the Deluge gather round Ararat. The garden of Eden is placed in the valley of the Araxes; Marand is the burial-place of Noah's wife; at Arghuri, a village near the great chasm, was the spot where Noah planted the first vineyard, and here were shown Noah's vine, and the monastery of St James, until village and monastery were overwhelmed by a fall of rock, ice, and snow, shaken down by the earthquake of 1840. Since 1856 Ararat has been climbed by Bryce (1876), Markoff (1888), Pastuchow and Lynch (1893).

BRYCE, *Transcaucasia and Ararat*, 4th ed. 1896.—LYNCH, *Armenia.* London, 1901. (C. W. W.)

Ararat, a municipality and railway station in Australia, Victoria, in the county of Ripon, 131½ postal miles N.W. of Melbourne, with which it is connected (*viâ* Ballarat) by rail. It is the commercial centre of the north-western grain and wool producing district, and is also noted for its quartz and alluvial gold mines. Excellent wine is made. The district also yields the best timber in great quantity. Granite, bluestone, limestone, and slate abound in the neighbourhood. It has a large lunatic asylum, and is an assize town. Altitude, 1072 feet. Rainfall (14 years), 24·37 inches. Population (1881), 2740; (1891), 3151; (1901), 3580.

Aras, *Araxes*, a river which rises in the Bin-geul Dagh, south of Erzerûm, and, after flowing eastward through the territories of Turkey and Russia, forms the boundary between Persia and Russia. It formerly joined the Kur, but since 1897, when it changed its lower course, it has run direct to the Kizil Agach Bay of the Caspian.

Arauan. See SAHARA.

Arbela, now Erbîl, a small town east of the Tigris, in the Mosul vilâyet. The battle in which Alexander defeated Darius was fought at Gaugamela, on the Bumodus, now Khazr Su, a tributary of the Greater Zab, and not at Arbela. In the 14th century the Christians were massacred and almost exterminated. Population, 4000.

Arbitrage.—Arbitrage is the term applied to the system of equalizing prices in different commercial centres by buying in the cheaper market and selling in the dearer. These transactions, or their converse, are mainly confined to stocks and shares, foreign exchanges, and bullion; and are for the most part carried on between London and the Continental capitals, and largely with New York. When prices in London are affected by financial or political causes, all other markets are sooner or later influenced, as London is the banking and financial centre for the commerce of the world. It may, however, also occur that some local event of importance initiates a rise or fall in a particular market which must ultimately affect other countries. For instance, a revolution or a threat of one in France would immediately depress all French securities, and by exciting the fears of capitalists would stimulate transfers of funds and raise all the exchanges against France.

In ordinary times those engaged in arbitrage operate with a very small margin of profit. The great improvement in postal, telegraphic, and telephonic communication enables operators to close transactions with amazing rapidity, while competition reduces the margin of profit to a minimum. Operations in American stocks and shares are carried on between London and New York on a vast scale, while transactions in African mining shares are undertaken to a considerable extent between London and Paris. The frequent fluctuations in the prices of the latter securities offer a large and fruitful field to bold operators possessed of large resources, while those who have small means often succumb in a commercial crisis. As regards foreign exchange and bullion, arbitrage operators stand on a fairly safe foundation, the fluctuations being slight and involving little or no risk, although they yield a very small margin of profit. In fact arbitrage between London and the continent of Europe has dwindled, owing to competition, to almost vanishing point, but operations with distant countries such as India are large and mainly profitable. Arbitrage with India consists chiefly in buying bills of exchange in London, such as India Council rupee bills amounting to about 16 millions sterling annually, and commercial bills drawn against goods exported to India. The counter-operation consists in purchasing in India, for short or long delivery, sterling bills drawn against exports to Great Britain of Indian produce, such as cotton, tea, indigo, jute, and wheat. These operations greatly facilitate trade and the moving of produce from the interior of India to the seaports. Without this assistance Great Britain's enormous trade could not be carried on, and she would have to revert to the primitive system of barter. The same advantages are afforded to her vast trade with China and Japan, with the material difference that the supply of Government council bills is confined to the Indian trade. The balance of trade with all countries is generally settled by specie shipments; hence, with the Far East, silver and gold play an important part in arbitrage.

It is impossible to imagine the difficulties and confusion which would arise in the absence of the arbitrageur. It is the system of arbitrage, based on principles which are the necessary outcome of successful commerce, which renders vast operations possible, and greatly facilitates the enormous British export and import trade, while maintaining those international connexions which tend to secure general peace and prosperity. (S. M.)

Arbitration.—Since the publication of the ninth edition of this work the law as to arbitration has, both in England and Scotland, undergone considerable modification. The principal changes in the English law have been made by the Arbitration Act, 1889. This statute—which, it should be noted, is an express code as to proceedings in all arbitrations—subdivides its subject matter into two headings:—I. References by consent out of court; II. References under order of court.

I. *References by Consent out of Court.*—Here the first matter to be dealt with is the submission. A submission is defined as a written agreement (which must be signed by both parties or their authorized agents) to submit present or future differences to arbitration, whether a particular arbitrator is named in it or not. Under the law prior to the Act of 1889, (*a*) an agreement to refer disputes generally, without naming the arbitrators, was always irrevocable, and an action lay for the breach of it, although the court could not compel either of the parties to proceed under it; (*b*) an agreement to refer to a particular arbitrator was revocable, and if one of the parties revoked that particular arbitrator's authority he could not be compelled to submit to it; (*c*) when, however, the parties had got their tribunal fixed, and were proceeding to carry out the agreement to refer, the Act 9 and 10 Will. III. c. 15 provided that the submission might be made a rule of court, a provision which gave the court power to assist the parties in the trial of the case, and to enforce the award of the arbitrators; (*d*) the statute 3 and 4 Will. IV. c. 42 put an end to the power to revoke the authority of a particular arbitrator after the reference to him had been made a rule of court; and—a liability which existed also under the Act of 9 and 10 Will. III. c. 15—any person revoking the appointment of an arbitrator after the submission had been made a rule of court might be attached. The Arbitration Act, 1889, provides that a submission, unless a contrary intention is expressed in it, is irrevocable except by leave of the court or a judge, and is to have the same effect in all respects as if it had been made an order of court. The object of this enactment was to save the expense of making a submission a rule of court by treating it as having been so made, and it leaves the law in this position, that while the authority of an arbitrator, once appointed, is irrevocable, there is no power—any more than there was under the old law—to compel an unwilling party to proceed to a reference, except in cases specially provided for by sections 5 and 6 of the Act of 1889. The former of these sections deals with the power of the court, the latter with the power of the parties to a reference, to appoint an arbitrator in certain circumstances. Section 5 provides that where a reference is to be to a single arbitrator, and all the parties do not concur in appointing one, or an appointed arbitrator refuses to act or becomes incapable of acting, or where the parties or two arbitrators fail, when necessary, to appoint an umpire or third arbitrator, or such umpire or arbitrator when appointed refuses to act, or becomes incapable of acting, and the default is not rectified after seven clear days' notice, the court may supply the vacancy. Under section 6, where a reference is to two arbitrators, one to be appointed by each party, and either the appointed arbitrator refuses to act, or becomes incapable of acting, and the party appointing him fails, after seven clear days' notice, to supply the vacancy, or such party fails, after similar notice, to make an original appointment, a binding appointment (subject to the power of the court to set it aside) may be made by the other party to the reference. The court may compel parties to carry out an arbitration not only in the above cases by directly appointing an arbitrator, &c., or by allowing one appointed by a party to proceed alone with the reference, but also indirectly by staying any proceedings before the legal tribunals to determine matters which come within the scope of the arbitration. The court will generally stay proceedings where the agreement to refer stipulates that the submission of a dispute to arbitration shall be a condition precedent to the right to bring an action in regard to it. On the other hand, the court will refuse to interfere if the subject matter of the litigation falls outside the scope of the reference, or there is some serious objection to the fitness of the arbitrator, or some other good reason of the kind exists.

An arbitrator (and the following observations apply *mutatis mutandis* to an umpire after he has entered on his duties) has power to administer oaths to, or take the affirmations of the parties and their witnesses; and any person who wilfully gives false evidence before him may be prosecuted and punished for perjury. At any stage in the reference he may, and shall if he be required by the court, state in the form of a special case for the opinion of the court any question of law arising in the arbitration. The arbitrator may also state his award in whole or in part as a special case, and may correct in an award any clerical mistake or error arising from an accidental slip or omission. The costs of the reference and the award are in his discretion, and he has a lien on the award and the submission for his fees, for which, apparently—unless upon an express promise to pay them—he cannot sue.

If there is no express provision on the point in the submission, an award under the Arbitration Act, 1889, must be made within three months after the arbitrator has entered on the reference, or been called upon to act by notice in writing from any party to the submission. The time may, however, be extended by the arbitrator or by the Court. An umpire is required to make his award within one month after the original or extended time appointed for making the award of the arbitrators has expired, or any later day to which he may enlarge it. The court may by order remit an award to the arbitrators or umpire for reconsideration, in which case the reconsidered award must be made within three months after the date of the order. An award may be set aside where the arbitrator has misconducted himself (an arbitrator may also be removed by the court on the ground of misconduct), or where it is *ultra vires*, or the arbitrator has been wilfully deceived by one of the parties, or some such state of things exists. Otherwise it is final. An award may, by leave of the court, be enforced in the same manner as a judgment or decree to the same effect. Under the Stamp Act, 1891, duties ranging from 3d. up to £1, 15s. are payable on awards in England or Ireland.

Provisions for the arbitration of special classes of disputes are contained in many Acts of Parliament (see, *e.g.*, the Local Government Acts, 1888 and 1894, and the Workmen's Compensation Act, 1897).

It may also be noted here that the Conciliation Act, 1896, provides machinery for the prevention and settlement of trade disputes, and that in 1892 a chamber of arbitration for business disputes was established by the joint action of the Corporation of the City of London and the London Chamber of Commerce.

II. *References under Order of Court.*—The court or a judge may refer any question arising in any cause or matter to an official or special referee, whose report may be enforced like a judgment or order to the same effect. This power may be exercised whether the parties desire it or not. The official referees are salaried officers of court. The remuneration of special referees is determined by the court or judge. An entire action may be referred, if all parties consent, or if it involves any prolonged examination of documents, or scientific or local examination, or consists wholly or partly of matters of account.

Scotland.—The law of arbitration has been modified by the Arbitration (Scotland) Act, 1894. An agreement to refer to a person not named or to be named by another person, or to the holder for the time being of any office, is now valid. The court (*i.e.*, any lord ordinary of the Court of Session or sheriff) may appoint an arbiter, on the failure of one of the parties on whom the obligation rests to concur in or make such an appointment. Where arbiters differ in opinion, they, or (if they fail to agree on the point) the court, on the application of either party, may nominate an oversman whose decision is to be final.

The provisions of the English Arbitration Act, 1889, have in substance been adopted by the Indian Legislature (see Act No. 9 of 1899), and by many of the Colonies (see, *e.g.*, Act No. 13 of 1895, Western Australia; No. 24 of 1898, Natal; No. 20 of 1899, Bahamas).

United States.—Arbitration is ordinarily conducted out of court, but in most States an agreement to settle a controversy in this way may be filed in court, and enforced by its authority. There are also statutes of the United States providing facilities for adjusting disputes between certain classes of employers and workmen in this way. The United States law allows arbitration proceedings between corporations engaged in commerce, between the States and their employees, to take place before official arbitrators and at the public expense (30 United States statutes at large, 424).

AUTHORITIES.—RUSSELL, *Arbitration*, London, 1900; *Annual Practice*, London, 1901.—REDMAN, *Arbitration*, London, 1897. —CREWE, *Arbitration Act of* 1889, London, 1898. As to Scots Law, *Green's Encyclopædia of Scots Law*, vol. i. s.v. "Arbitration," Edinburgh, 1896.

(A. W. R.)

ARBITRATION AND CONCILIATION IN LABOUR DISPUTES.

THE terms "arbitration and conciliation," as employed in this article, are used to describe a group of methods of settling disputes between employers and work-people or among two or more sets of work-people, of which the common feature is the intervention of some outside party not directly affected by the dispute. If the parties agree beforehand to abide by the award of the third party, the mode of settlement is described as "arbitration." If there be no such agreement, but the offices of the mediator are used to promote an amicable arrangement between the parties themselves, the process is described as "conciliation." The third party may be one or more disinterested individuals, or a joint-board representative of the parties or of other bodies or persons.

The process here termed "arbitration" is rarely an arbitration in the strict legal sense of the term (at least in the United Kingdom), because of the defective legal personality of the associations or groups of individuals who are usually parties to labour disputes, and the consequent absence in the great majority of cases of a valid legal "submission" of the difference to arbitration. Trade unions, whether consisting of employers or workmen, in the United Kingdom are not corporate bodies capable of entering through their agents into legally binding contracts. Consequently a written agreement on the part of the representatives of employers and workmen to submit a dispute to the decision of a third party is of no legal force except as regards the actual signatories.[1] Broadly speaking, therefore, the provisions of the Arbitration Act, 1889, which consolidated the law relating to arbitration in general, would as a rule have no application to the settlement of collective disputes between employers and workmen, even if the Act had not been expressly excluded by section 3 of the Conciliation Act of 1896 in the case of disputes to which that Act applies. Besides the absence of a legal "submission," labour arbitrations differ from ordinary arbitrations in the fact that the questions referred often (though by no means always) relate to the terms on which future contracts shall be made, whereas the vast majority of ordinary arbitrations relate to questions arising out of existing contracts. The defective "personality" of the parties to labour disputes also prevents the enforcement of an award by legal penalties. Since, however, difficulties of enforcement affect not only settlements arrived at by arbitration, but all agreements between bodies of employers and work-people with regard to the terms of employment, they are most appropriately considered at a later stage of this article.

The term "conciliation" is ordinarily used to cover a large number of methods of settlement, shading off in the one direction into "arbitration" and in the other into ordinary direct negotiation between the parties. In some cases conciliation only differs from arbitration in the absence of a previous agreement to accept the award. The German "*Gewerbegerichten*," when dealing with labour disputes, communicate a decision to both parties, who must notify their acceptance or otherwise (see below). The State Board in Massachusetts sometimes takes similar action.

The conciliation boards established under the New Zealand Arbitration Act of 1894 (see below) make recommendations, though either side may decline to accept them and may appeal to the Court of Arbitration, which in that colony has compulsory powers. Most frequently, however, in Great Britain the mediating party abstains from pronouncing a definite judgment of his own, but confines himself to friendly suggestions with a view of removing obstacles to an agreement between the parties. On the other hand, it is not easy to define how far the "outside party" must be independent of the parties to the dispute, in order that the method of settlement may be properly described as "conciliation." There is a sense in which a friendly conversation between an employer or his manager and a deputation of aggrieved workmen is rightly described as "conciliation," but such an interview would certainly not be covered by the term as ordinarily used at the present day. Again, when the parties are represented by agents (*e.g.*, the officials of an employers' association and of a trade union) the actual negotiators or some of them may not personally be affected by the particular dispute, and may often exercise some of the functions of the mediator or conciliator in a manner not clearly to be distinguished from the action of an outside party. It seems best, however, to exclude such negotiations from our purview so long as those between whom they are carried on merely act as the authorized agents for the parties affected. In the same way a meeting arranged *ad hoc* between delegates of an employers' association and a trade union, for the purpose of arranging differences as to the terms on which the members of the association shall employ members of the union is not usually classed as "conciliation," unless the meeting is held in the presence of an independent chairman or conciliator, or in pursuance of a permanent agreement between the associations laying down the procedure for the settlement of disputes. If, however, the dispute is considered and arranged not by a casual meeting between two committees and deputations appointed *ad hoc*, but by a permanently organized "joint committee" or board with a constitution, rules of procedure, and officers of its own, the process of settlement is by ordinary usage described as "conciliation," even though the board be entirely representative of the persons engaged in the industry. Such joint boards, as will be seen, play a most important part in conciliation at the present day, and they almost always have attached to them some machinery for the ultimate decision by arbitration of questions on which they fail to agree. Another form of conciliation is that in which the mediating board represents a wider group of industries than those affected by the dispute (*e.g.*, the London and other "district" boards referred to below). Moreover, in some of the most important cases of settlement of disputes by conciliation, the mediating party has not been a permanent board but a disinterested individual, *e.g.*, the mayor, county court judge, government official, or member of parliament. As will be seen below, the Conciliation Act now provides for the appointment of "conciliators" by the Board of Trade.

Voluntary trade boards, however (*i.e.*, permanent joint boards representing employers and work-people in particular trades), are at once the most firmly established and the most important agencies in Great Britain for the prevention and settlement of labour disputes. Among the earliest of such bodies was the board of arbitration in the Macclesfield silk trade, formed in 1849, in imitation of the French "*Conseils des Prud'hommes*," but which only lasted four years. The first board, however, which attained any degree of permanent success was that established for the hosiery and glove trade in Nottingham in 1860, through the efforts of Mr Mundella. In 1864 a board was established in the Wolverhampton building trades, with Mr (afterwards Sir) Rupert Kettle as chairman, and in 1868 boards were formed for the pottery trade, the Leicester hosiery trade, and the Nottingham lace trade. Of the above boards only the last-named is still actively in existence, though a joint committee still exists for settling minor questions in the pottery trade. In 1869, however, there was formed one of the most important of the still existing boards, viz., the board of arbitration and conciliation in the manufactured iron and steel trades of the north of England, with which the names of Rupert Kettle, David Dale, and others are associated. In 1872 joint committees were formed in the Durham and Northumberland coal trades to deal with local questions. The Leicester boot and shoe trade board, the first of an elaborate system of local boards in this trade, was founded in 1875. From about 1870 onwards there was a great movement for the establishment of "sliding scales" in the coal and iron and steel trades, which by regulating wages automatically rendered unnecessary the settlement of general wages by conciliation or arbitration. These sliding scales, however, usually had attached to them joint committees for dealing with disputed questions. A sliding scale arranged by Mr (since Sir) David Dale was attached to the manufactured iron trade board in 1871. A sliding scale for the Cleveland blast furnacemen came into force in 1879. Sliding scales were also adopted in the coal trade in many districts, *e.g.*, South Wales (1875), Durham (1877), and Northumberland (1879). The movement was, however, followed by a reaction, and several of the sliding scales in the coal trade were terminated between 1887 and 1889.

---

[1] The House of Lords decided, in the Taff Vale Railway case (1901), that trade unions may be sued *in tort*, but the decision does not refer to their status as regards contracts.

The formation on a large scale of conciliation boards in the coal trade to fix the rate of wages dates from the great miners' dispute of 1893, one of the terms of settlement agreed to at the conference held at the Foreign Office under Lord Rosebery being the formation of a conciliation board covering the districts affected. Northumberland followed in 1894, Durham in 1895, Scotland in 1900.

The first general district board to be formed was that established in London in 1890, through the London Chamber of Commerce, as a sequel to the Mansion House committee which mediated in the great London dock strike of 1889. The example has been followed by several large towns, but the action taken by the boards in some of these provincial districts has been very limited.

Constitution and functions of voluntary conciliation boards.

The most typical form of machinery for the settlement of disputes by voluntary conciliation is a joint board consisting of equal numbers of representatives of employers and employed. The members of the board are usually elected by the associations of employers and workmen, though in some cases (*e.g.*, in the manufactured iron trade board) the workmen's representatives are elected not by their trade union but by meetings of workmen employed at the various works. The chairman may be an independent person, or, more usually, a representative of the employers, the vice-chairman being a representative of the workmen. In the arbitration and conciliation boards in the boot and shoe trade, provision is made by which the chair may be occupied by representatives of the employers and workmen in alternate years. An independent chairman usually has a casting vote, which practically makes him an umpire in case of equal voting, but where there is no outside chairman there is usually provision for reference of cases on which the board cannot agree to an umpire, who may either be a permanent officer of the board elected for a period of time (as in the case of several of the boards in the boot and shoe trade), or selected *ad hoc* by the board or appointed by some outside person or body. Thus the choice of the permanent chairman or umpire of the miners' conciliation board, formed in pursuance of the settlement of the coal dispute of 1893 by Lord Rosebery, was left to the Speaker of the House of Commons. Since the passing of the Conciliation Act, several conciliation boards have provided in their rules for the appointment of umpires by the Board of Trade.

Conciliation boards constituted as described above usually have rules providing that there shall always be equality of voting as between employer and workmen, in spite of the casual absence of individuals on one side or the other. In order to expedite business it is sometimes provided that all questions shall be first considered by a sub-committee, with power to settle them by agreement before coming before the full board. Boards of conciliation and arbitration conforming more or less to the above type exist in the coal, iron and steel, boot and shoe, and other industries in the United Kingdom. A somewhat different form of organization has prevailed in the cotton-spinning trade (since the dispute of 1892-93) and in the engineering trade (since the engineering dispute of 1897-98). In these important industries there are no permanent boards for the settlement of general questions, but elaborate agreements are in force between the employers' and workmen's organizations which among other things prescribe the mode in which questions at issue shall be dealt with and if possible settled. In the first place, if the question cannot be settled between the employer and his workmen, it is dealt with by the local associations or committees or their officials, and failing a settlement in this manner, is referred to a joint meeting of the executive committees of the two associations. In neither agreement is there any provision for the ultimate decision of unsettled questions by arbitration. The agreement in the cotton trade is known as the "Brooklands Agreement," and a large number of questions have been amicably settled under its provisions. In the building trade, in which (with the exception of the plumbers' board) there are at present no national arrangements for conciliation and arbitration, it is very customary for the local "working rules," agreed to mutually by employers and employed in particular districts, to contain "conciliation rules" providing for the reference of disputed questions to a joint committee with or without an ultimate reference to arbitration. Yet another form of voluntary board is the "district board," consisting in most cases of representatives elected in equal numbers by the local chamber of commerce and trades council respectively. In the case, however, of the London Conciliation Board the workmen's representatives are elected, twelve by specially summoned meetings of trade union delegates and two by co-optation. The functions of district boards are to deal with disputes in any trade which may occur within their districts, and of course they can only take action with the consent of both parties to the dispute, in this respect differing from the majority of "trade" boards, which, as a rule, are empowered by the agreement under which they are constituted to deal with questions on the application of either party. Another interesting type of board is that representing two or more groups of workmen and sometimes their employers, with the object of settling "demarcation" disputes between the groups of workmen (*i.e.*, questions as to the limits of the work which each group may claim to perform). Examples of such boards are those representing shipwrights and joiners on the Clyde, Tyne, and elsewhere. While the arrangements for voluntary conciliation and arbitration differ in this way in various industries, there is an equally wide variation in the character and range of questions which the boards are empowered to determine. For example, some boards in the coal trade (*e.g.*, the conciliation boards in Northumberland and the so-called "Federated Districts") deal solely with the general rate of wages. Othres, *e.g.*, the "joint committee" in Northumberland and Durham, confine their attention solely to local questions not affecting the counties as a whole. The Durham conciliation board deals with any general or county questions. This distinction between "general" and "local" questions corresponds nearly, though not entirely, to the distinction often drawn between questions of the terms of future employment and of the interpretation of existing agreements. Some conciliation boards are unlimited as regards the scope of the questions which they may consider. This was formerly the case with the boards in the boot and shoe trade, but under the "terms of settlement" of the dispute in 1895 drawn up at the Board of Trade, certain classes of questions (*e.g.*, the employment of particular individuals, the adoption of piece-work or time-work, &c.) were wholly or partially withdrawn from their consideration, and any decision of a board contravening the "terms of settlement" is null and void. A special feature in the procedure for conciliation and arbitration in the boot and shoe trade, is the deposit by each party of £1000 with trustees, as a financial guarantee for the performance of agreements and awards. A certain class of conciliation boards, mostly in the Midland metal trades, were attached to "alliances" of employers and employed, having for their object the regulation of production and of prices (*e.g.*, the Bedstead Trade Wages Board). Some of these alliances, however, have been dissolved.

Legislation in the United Kingdom.

At all events up to the year 1896, the development of arbitration and conciliation as methods of settling labour disputes in the United Kingdom was entirely independent of any legislation. Previously to the Conciliation Act of 1896 (described below) several attempts had been made by parliament to promote arbitration and conciliation, but with little or no practical result, and the Act of 1896 repealed all previous legislation on the subject, at the same time excluding the operation of the Arbitration Act of 1889 from the settlement of "any difference or dispute to which this Act applies." The laws repealed by the Conciliation Act need only a few words of mention. During the 18th century the fixing of wages by magistrates under the Elizabethan legislation gradually decayed, and the Acts 20 Geo. II. c. 19 and 31 Geo. II. c. 11, gave summary jurisdiction to justices of the peace to determine disputes between masters and servants in certain circumstances, although no rate of wages had been fixed that year by the justices of the peace of the shire. These and other laws, relating specially to disputes in the cotton-weaving trade, were consolidated and amended by the Arbitration Act of 1824. This Act seems chiefly to have been aimed at disputes relating to piece-work in the textile trades, though applicable to other disputes arising out of a wages contract. It expressly excluded, however, the fixing of a rate of wages or price of labour or workmanship at which the workmen should in future be paid unless with the mutual consent of both master and workmen. The Act gave compulsory powers of settling the disputes to which it relates on application of either party to a court of arbitrators representing employers and workmen nominated by a magistrate. The award could be enforced by distress or imprisonment. The Act was subsequently amended in detail, and by the "Councils of Conciliation Act" of 1867 power was given to the Home Secretary to license "equitable councils of conciliation and arbitration" equally representative of masters and workmen, who should thereupon have the powers conferred by the Act of 1824. The Act contains provisions for the appointment of conciliation committees, and other details which are of little interest seeing that the Act was never put into operation. Another amendment of the Act of 1824 was made by the Arbitration (Masters and Workmen) Act of 1872, which contemplated the conclusion of agreements between employers and employed, designating some board of arbitration by which disputes included within the scope of the former Acts should be determined. A master or workman should be deemed to be bound by an agreement under the Act, if he accepted a printed copy of the agreement and did not repudiate it within forty-eight hours. Like the previous legislation, however, the Act of 1872 was inoperative. The evidence given before the Royal Commission on Labour (1891-94) disclosed the existence of a considerable body of opinion in favour of some further action by the state for the prevention or settlement of labour disputes, and some impetus was given to the movement by the settlement through official mediation of several important disputes, *e.g.*, the great coal-miners' dispute of 1893 by a conference presided over by Lord Rosebery, the cab-drivers' dispute of 1894 by the mediation of the Home Secretary (Mr Asquith), and the boot and shoe trade dispute of 1895 by a Board of Trade conference under the chairmanship of Sir Courtenay Boyle. In these, and a few other less important cases, the intervention of the Board of Trade or other department took place without any special statutory sanction. The Conciliation Act passed in 1896 was framed with a view to giving express authorization to such action in the future.

This Act is of a purely voluntary character. Its most important provisions are those of section 2, empowering the Board of Trade in cases "where a difference exists or is apprehended between any employer, or any class of employers, and workmen, or between different classes of workmen," to take certain steps to promote a settlement of the difference. They may of their own initiative hold an inquiry or endeavour to arrange a meeting between the parties under a chairman mutually agreed on or appointed from the outside, and on the application of either party they may appoint a conciliator or a board of conciliation who shall communicate with the parties and endeavour to bring about a settlement and report their proceedings to the Board of Trade. On the application of both parties the Board of Trade may appoint an arbitrator. In all cases the Board of Trade has discretion as to the action to be taken, and there is no provision either for compelling the parties to accept their mediation or to abide by any agreement effected through their intervention. There are other provisions in the Act providing for the registration of voluntary conciliation boards, and for the promotion by the Board of Trade of the formation of such boards in districts and trades in which they are deficient. During the first five years after the passage of the Act (*i.e.*, up to the middle of 1901) the number of cases arising under section 2 (providing for action by the Board of Trade for the settlement of actual or apprehended disputes) was 113, and the number of settlements effected 70. Of the 43 disputes not settled under the Act, 10 were settled between the parties during the negotiations, and in 33 cases the applications were refused by the Board of Trade, or their efforts to effect a settlement were unsuccessful. Of the 70 settlements, 32 were effected by conciliation and 38 by arbitration. At present, however, the number of cases of arbitration under the Act appears to be increasing compared with those of conciliation, and several voluntary conciliation boards formed or reorganized since the passage of the Act provide in their rules for an appeal to the Board of Trade to appoint an umpire in case of a deadlock. Eighteen boards are known to have already adopted this course. The figures given above show that the Conciliation Act of 1896 has by no means, like previous legislation, been a dead letter, though the number of actual disputes settled is naturally small compared with the total number annually recorded. In spite of the complete discretion given to the Board of Trade as regards the offer of its services and to the parties as regards acceptance of its intervention, experience in the great engineering dispute of 1897 and the South Wales coal dispute of 1898, appears to show that public opinion may put pressure on the Board to attempt mediation in a dispute which has attracted popular attention, whatever may be the attitude of the parties directly concerned; and there has been a tendency in some cases to make the action or inaction of the Department a subject of parliamentary debate. Under these conditions intervention must sometimes lead to disappointment, and the danger must also be borne in mind that the expectation of official intervention may occasionally lead the losing side to prolong a hopeless dispute. If, however, direct official mediation in labour disputes is attended with difficulties, these do not apply to the appointment by the Board of Trade of umpires and arbitrators, on an application by both parties or by a voluntary conciliation board.

Proposals for compulsion.

Arbitration and conciliation in labour disputes as practised in the United Kingdom are entirely voluntary, both as regards the initiation and conduct of the negotiations and the carrying out of the agreement resulting therefrom. In all these respects arbitration, though terminating in what is called a binding award, is on precisely the same legal footing as conciliation, which results in a mutual agreement. Various proposals have been made (and in some cases carried into effect in certain countries) for introducing an element of compulsion into this class of proceeding. There are three stages at which compulsion may conceivably be introduced. (1) The parties may be compelled by law to submit their dispute to some tribunal or board of conciliation; (2) the board of conciliation or arbitration may have power to compel the attendance of witnesses and the production of documents; (3) the parties may be compelled to observe the award of the board of arbitration. The most far-reaching scheme of compulsory arbitration in force in any country is that embodied in the New Zealand Industrial Conciliation and Arbitration Act of 1894. Bills have been introduced into the British House of Commons for clothing voluntary boards of conciliation and arbitration, under certain conditions, with powers to require attendance of witnesses and production of documents, without, however, compelling the parties to submit their disputes to these boards or to abide by their decisions. In the United Kingdom, however, more attention has recently been given to the question of strengthening the sanction for the carrying out of awards and agreements than of compelling the parties to enter into such arrangements. An interesting step towards the solution of the difficulty of enforcement in certain cases is perhaps afforded by the provisions of the terms of settlement of the dispute in the boot and shoe trade drawn up at the Board of Trade in 1895. Under this agreement £1000 was deposited by each party with trustees, who were directed by the trust-deed to pay over to either party, out of the money deposited by the other, any sum which might be awarded as damages by the umpire named in the deed, for the breach of the agreement or of any award made by an arbitration board in consonance with it. Up to the present only one claim for damages has been sustained under this agreement, the amount of the damages given against the union being £300. Nevertheless it cannot be doubted that the pecuniary liability of the parties has given stability to the work of the local arbitration boards, and the satisfaction of both sides with the arrangement is shown by the fact that the trust-deed, which lapsed in March 1900, was renewed for a further period of two years. Theoretically a trust deed of this kind can only offer a guarantee up to the point at which the original deposit on one side or the other is exhausted, as it is impossible to compel either party to renew the deposit. A proposal was made by the Duke of Devonshire and certain of his colleagues on the Royal Commission on Labour for empowering associations of employers and employed to acquire, if they desired it, sufficient legal personality and corporate character to enable them to sue each other or their own members for breach of agreement. This would give the association aggrieved by a breach of award the power of suing the defaulting organization to recover damages out of their corporate funds, while each association could exact penalties from its members for such a breach. For this reason the suggestion has met with a good deal of support by those interested in arbitration and conciliation.

Apart, however, from any suspicions entertained of it by workmen's associations, the question is not free from difficulties. The object of the change would be to convert what are at present only morally binding understandings into legally enforceable contracts. But apart from the possibility that some of such contracts would be held by the courts to be void as being "in restraint of trade," the tendency might be to give a strict legal interpretation to working agreements which might deprive them of some of their effectiveness for the settlement of the conditions of future contracts between employers and workmen, while possibly deterring associations from entering into such agreements for fear of litigation. Individuals, moreover, could avoid liability by leaving their associations. Many persons are therefore of opinion that the present imperfect sanction for agreements and awards must be accepted as the lesser of two evils. In countries like New Zealand, where the parties are compelled to submit their differences to arbitration, some of the above objections do not apply.

Statistics of existing agencies.

The following statistics are based on the reports of the Labour Department of the Board of Trade on Strikes and Lock-outs. The number of boards of conciliation and arbitration known to have settled disputes in 1899 was 53, of which 50 come under the head of "trade," 2 of "district," and 1 of "general" boards. So far as known about 139 boards are in existence, but several of these did no active work in 1899. Of the 50 trade boards, 11 are connected with the boot and shoe trade, 9 with engineering and shipbuilding, 7 with coal-mining, 13 with iron and steel and other metal trades, 7 with the building trades, and the others with various miscellaneous industries. The importance of the questions dealt with by these boards differs so very greatly—ranging from the classification of a sample to an alteration of wages affecting hundreds of thousands of men—that the statistics of the number of cases settled tend to be somewhat misleading. Nevertheless the following figures may be of some interest. Altogether, 1232 cases were considered by the boards in 1899, of which 506 were withdrawn or settled independently of the boards, and 51 were still unsettled at the end of the year. The remaining 675 cases were settled, 503 by the board or committees and 172 by arbitrators or umpires. The great majority of the cases settled were purely local questions. Thus 350 cases—or more than half the total—were dealt with by the "joint committees" in the Northumberland and Durham coal trades, which confine their action to local questions, such as fixing the "hewing prices" for new seams. Of the remaining 325 cases, 125 are accounted for by the boot and shoe trade. Here again a large majority of the cases were questions of classifying sample boots, shoes, or materials, *i.e.*, of determining under what heading of the existing piece-work lists a new pattern of boot or a new quality of material ought properly to be classified. During the year, however, several more general questions, *e.g.*, rates of a minimum wage and overtime payment, affecting considerable bodies of men, were determined by the boot and shoe trade boards or their umpires. Thirty-nine cases were settled by a board for the tailoring trade in Aberdeen—all of minor importance. The iron and steel trades account for 30 cases, and engineering and shipbuilding for 81. Among the latter are included a considerable number of "demarcation disputes," *i.e.*, disputes between two bodies of workmen as to the limits of the work to be performed by each. Four joint boards representing shipwrights and joiners on the Tyne, Tees, and Clyde respectively, settled 57 such cases in 1899, of which only 4 were relegated to umpires. The great majority of the above cases did not actually involve stoppage of work, the most useful work of these permanent boards being the prevention rather than the settlement of strikes and lock-outs. During 1899 only 10 strikes were settled by permanent boards—in 1898 the number being 19, and in 1897, 12. In none of these years were any of these strikes of great importance. A certain number of disputes are settled every year by the mediation or arbitration of disinterested individuals, *e.g.*, the local mayor or county court judge. The number of strikes so settled in 1899 was 26, and in the previous year 16.

The operations under the Conciliation Act have been separately described above. Altogether, if the work of all agencies for conciliation and arbitration be included, the number of strikes and lock-outs settled by these means in 1899 was 38. During the five years 1894-99 the annual number of strikes so settled varied between 38 and 45. The number of work-people affected by these disputes in 1899 was 11,705, or about 6 per cent. of the persons involved in all the 719 disputes recorded in that year. It is clear from the above figures that the most important and most hopeful part of the work of agencies for conciliation and arbitration is the adjustment of differences that might otherwise lead to stoppage, rather than the settlement of actual strikes.

Future scope and limits.

The extent to which the methods of arbitration and conciliation can be expected to afford a substitute for strikes and lock-outs is one on which opinions differ very widely. The difficulties arising from the impossibility of enforcing agreements or awards by legal process have already been discussed. Apart from these, however, it is evident that both methods imply that the parties, especially the work-people, are organized at least to the extent of being capable of negotiating through agents. In some industries (*e.g.*, agriculture or domestic service) this preliminary condition is not satisfied; in others the men's leaders possess little more than consultative powers, and employers may hesitate to deal either directly or through a third party with individuals or committees who have so little authority over those whom they claim to represent. And even where the trade organizations are strong, some employers object in any way to recognize the representative character of the men's officials. Recent cases of this kind that attracted attention were Lord Penrhyn's refusal to recognize the Quarrymen's Union or the quarry committee as representing his quarrymen, and the refusal of several important railway companies to deal with the Amalgamated Society of Railway Servants. The question of the "recognition" of trade unions by employers is a frequent cause of disputes, and is further referred to in the article on STRIKES AND LOCK-OUTS. It may be observed, however, that it frequently occurs that in cases in which both employers and employed are organized into associations which are accustomed to deal with each other, one or both parties entertain a strong objection to the intervention of any outside mediator, or to the submission of differences to an arbitrator. Thus the engineering employers in 1897 were opposed to any outside intervention, though ready to negotiate with the delegates chosen by the men. On the other hand, the cotton operatives have more than once opposed the proposal of the employers to refer the rate of wages to arbitration, and throughout the great miners' dispute of 1893 the opposition to arbitration came from the men. Naturally, the party whose organization is the stronger is usually the less inclined to admit outside intervention. But there have been several recent cases in which employers, who refused to deal directly with trade union officials, have been willing to negotiate with a mediator who was well known to be in communication with these officials (*e.g.*, in some of the recent railway disputes).

Apart, however, from the disinclination of one or both parties to allow of any outside intervention, we have to consider how far the nature of the questions in dispute may in any particular case put limits to the applicability of conciliation or arbitration as a method of settlement. Since conciliation is only a general term for the action of a third party in overcoming the obstacles to the conclusion of an agreement by the parties themselves, there is no class of questions which admit of settlement by direct negotiation which may not equally be settled by this method, provided of course that there is an adequate supply of sufficiently skilful mediators. As regards arbitration the case is somewhat different, seeing that in this case the parties agree to be bound by the award of a third party. For the success of arbitration, therefore, it is important that the general principles which should govern the settlement of the particular question at issue should be admitted by both sides. Thus in the manufactured iron trade in the north of England, it has throughout been understood that wages should depend on the prices realized, and the only question which an arbitrator has usually had to decide has been how far the state of prices at the time warranted a particular change of wage. On the other hand, there are many questions on which disputes arise (*e.g.*, the employment of non-union labour, the restriction of piece-work, &c.) on which there is frequently no common agreement as to principles, and an arbitrator may be at a loss to know what considerations he is to take into account in determining his award. Generally speaking, employers are averse from submitting to a third party questions involving discipline and the management of their business, while in some trades workmen have shown themselves opposed to allowing an arbitrator to reduce wages beyond a certain point which they wish to regard as a guaranteed "minimum."

Another objection on the part of some employers and workmen to unrestricted arbitration is its alleged tendency to multiply disputes by providing an easy way of solving them without recourse to strikes or lock-outs, and so diminishing the sense of responsibility in the party advancing the claims. It is also sometimes contended that arbitrators, not being governed in their decisions by a definite code of principles, may tend to "split the difference," so as to satisfy both sides even when the demands on one side or the other are wholly unwarranted. This, it is said, encourages the formulation of demands purposely put high in order to admit of being cut down by an arbitrator. One of the chief practical difficulties in the way of the successful working of permanent boards of conciliation, consisting of equal numbers of employers and employed, with an umpire in case of deadlock, is the difficulty of inducing business men whose time is fully occupied to devote the necessary time to the work of the boards, especially when either side has it in its power to compel recourse to the umpire, and so render the work of the conciliation board fruitless. In spite of all these difficulties the practice of arranging differences by conciliation and arbitration is undoubtedly spreading, and it is to be remembered that even in cases in which theoretically a basis for arbitration can scarcely be said to exist, recourse to that method may often serve a useful purpose in putting an end to a deadlock of which both parties are tired, though neither cares to own itself beaten.

Colonial and foreign legislation.

Reference must now be made to some of the principal laws relating to arbitration and conciliation outside the United Kingdom.

New Zealand.—The New Zealand Industrial Conciliation and Arbitration Act, 1894 (amended in detail by several subsequent Acts), provides for the incorporation of associations of employers or workmen under the title of industrial unions, and for the creation in each district of a joint conciliation board, elected by these industrial unions, with an impartial chairman elected by the board, to which a dispute may be referred by any party, a strike or lock-out being thenceforth illegal. If the recommendation of the conciliation board is not accepted by either party, the matter goes to a court of arbitration consisting of two persons representing employers and workmen respectively, and a judge of the supreme court. The award of this court is enforceable by legal process, financial penalties up to £500 being recoverable from defaulting associations or individuals. If the property of an association is insufficient to pay the penalty, its members are individually liable up to £10 each. During the year 1899-1900 thirty-four cases were considered by the conciliation boards, and twenty were sent to the arbitration court. In addition, nine cases of breach of award or agreement were dealt with.

The above is only an outline of the principal provisions of this interesting Act, under which questions of wages, hours, and the relations of employers and workmen generally in New Zealand are now practically the subject of state regulation. Whatever may be the result of the Act when its indirect effects have had time to develop, it is clear that it goes far beyond the mere settlement of strikes, and is more properly to be judged as a measure for the state regulation of industry.

New South Wales.[1]—In New South Wales a "Conciliation and Arbitration Act" was passed in 1899, resembling the United Kingdom Act in the general character of its provisions, except that an arbitrator or investigator appointed by Government is invested with compulsory powers of summoning witnesses, entering premises, and examining on oath.

Canada.—In 1900 a Conciliation Act was passed by the Dominion Parliament resembling the United Kingdom Act in most of its features.

France.—The French Conciliation and Arbitration Law of December 1892 provides that either party to a labour dispute may apply to the *juge de paix* of the canton, who informs the other party of the application. If they concur within three days, a joint committee of conciliation is formed of not more than five representatives of each party, which meets in the presence of the *juge de paix*, who, however, has no vote. If no agreement results the parties are invited to appoint arbitrators. If such arbitrators are appointed and cannot agree on an umpire, the president of the civil tribunal appoints an umpire. In the case of an actual strike, in the absence of an application from either party it is the duty of the *juge de paix* to invite the parties to proceed to conciliation or arbitration. The results of the action of the *juge de paix* and of the conciliation committee are placarded by the mayors of the communes affected. The law leaves the parties entirely free to accept or reject the services of the *juge de paix*. During the seven years 1893-99 the Act was put in force in 778 cases—viz., 425 on application of workmen, 23 of employers, 18 of both sides, and 312 without application. Altogether, 204 disputes were settled—88 per cent. by conciliation and 12 per cent. by arbitration.

Germany.—In several Continental countries, courts or boards are established by law to settle cases arising out of existing labour contracts—*e.g.*, the French "*Conseils des Prud'hommes*," the Italian "*Probi Viri*," and the German "*Gewerbegerichten*,"—and some of the questions which come before these bodies are such as might be dealt with in England by voluntary boards or joint committees. The majority, however, are disputes between individuals as to wages due, &c., which would be determined in the United Kingdom by a court of summary jurisdiction. It is noteworthy, however, that the German industrial courts (*Gewerbegerichten*) are empowered under certain conditions to offer their services to mediate between the parties to an ordinary labour dispute. In the case of a strike or lock-out the court must intervene on application of both parties, and may do so of its own initiative or on the invitation of one side. Failing a settlement at a conference between the parties in the presence of the president and assessors of the court, the court arrives at a decision on the merits of the dispute which is communicated to the parties, who are allowed a certain time within which to notify their acceptance or rejection. The court has no power to compel the attendance of the parties or the observance of its decision. During 1896 there were 44 applications for the intervention of the Industrial Courts. Eighteen agreements were brought about and 11 decisions were pronounced by the courts, of which 2 were accepted by both parties and 9 were rejected. In 8 cases the courts made unsuccessful attempts to promote settlements without pronouncing decisions. The above figures are taken from a statement prepared for the Reichstag commission for considering petitions (1897-98).

Switzerland.—The canton of Geneva enacted a law in 1900 providing for the settlement by negotiation, conciliation, or arbitration of the general terms of employment in a trade, subject, however, to special arrangements between employers and workmen in particular cases. The negotiations are to take place between delegates chosen by the associations of employers and employed, or failing them, by meetings summoned by the Council of State on sufficient applications. Failing settlement, the Council of State, on application from either party, is to appoint one or more conciliators from its members, and if this fail the central committee of the "Prud'hommes," together with the delegates of employers and workmen, is to form a board of arbitration, whose decision is binding. Any collective suspension of work is illegal during the period covered by the award or agreement.

United States.—In the United States several States have legislated on the subject of conciliation and arbitration, among the first of such Acts being the "Wallace" Act of 1883, in Pennsylvania, which, however, was almost inoperative. Altogether, 24 States have made constitutional or statutory provision for mediation in trade disputes, of which 17 contemplate the formation of permanent State boards. The only State laws which require notice are those of Massachusetts and New York providing for the formation of State boards of arbitration. The Massachusetts board, founded in 1886, consists of one employer, one employed, and one independent person chosen by both. The New York board (1886) consists of two representatives of different political parties, and one member of a *bona-fide* trade organization within the State. In both States it is the duty of the board, with or without application from the parties, to proceed to the spot where a labour dispute has occurred, and to endeavour to promote a settlement. The parties may decline its services, but the board is empowered to issue a report, and on application from either side to hold an inquiry and publish its decision, which (in Massachusetts) is binding for six months, unless sixty days' notice to the contrary is given by one side to the other. Several States (including Massachusetts and New York) provide not only for State boards, but also for local boards.

---

[1] Since this article was written a compulsory Arbitration Law has been passed in New South Wales (December 1901).

In Massachusetts, during 1899, the State board had its attention directed to 25 disputes (several, as in previous years, being in the boot and shoe trade). Of these it settled 1 by arbitration, and in 6 others promoted a settlement by conciliation. The remaining cases were settled independently of the Board, or were unsettled when the Report was issued.

Federal legislation can only touch the question of arbitration and conciliation so far as regards disputes affecting commerce between different States. Thus an Act of June 1898 provides that in a dispute involving serious interruption of business on railways engaged in inter-State commerce, the Chairman of the inter-State Commerce Commission and the Commissioner of Labour shall, on application of either party, endeavour to effect a settlement, or to induce the parties to submit the dispute to arbitration. While an arbitration under the Act is pending a strike or lock-out is unlawful.

AUTHORITIES.—For the recent development of arbitration and conciliation in the United Kingdom, see the *Annual Reports of the Labour Department of the Board of Trade on Strikes and Lock-outs* from 1888 onwards. Since 1890 these reports have contained special appendices on the work of arbitration boards. See also the *Labour Gazette* (the monthly journal of the Labour Department) from 1893 onward. The *Reports of the Royal Commission on Labour* (1891-94) contain much valuable information on the subject. For the working of the Conciliation Act see the Reports of the Board of Trade on their proceedings under the Conciliation Act, 1896. For the earlier history in the United Kingdom—CROMPTON, *Industrial Conciliation* (1876); PRICE, *Industrial Peace* (1887). For foreign and colonial developments—the Report of the French *Office du Travail*, *De la Conciliation et de l'Arbitrage dans les Conflits Collectifs entre Patrons et Ouvriers en France et à l'Étranger* (1893); the Annual Reports of the same Department on *Strikes, Lock-outs, and Arbitration*; the *Reports of the Massachusetts and New York State Arbitration Boards*, and of the *New Zealand Department of Labour*; and the *Labour Gazette*.

ARBITRATION INTERNATIONAL.

INTERNATIONAL arbitration is a proceeding in which two nations refer their differences to one or more selected persons, who, after affording to each party an opportunity of being heard, pronounce judgment on the matters at issue. It is understood, unless otherwise expressed, that the judgment shall be in accordance with the law by which civilized nations have agreed to be bound whenever such law is applicable. An international arbitrator may be the chief of a friendly power, or he may be a private individual. When he is an emperor, a king, or a president of a republic, it is not expected that he will act personally; he may by tacit consent appoint a delegate or delegates to act on his behalf, and avail himself of their labours and views, the ultimate decision being his only in name. In this respect international arbitration differs from civil arbitration, since a private arbitrator cannot delegate his office without express authority. The analogy between the two fails to hold good in another respect also. In civil arbitration the decision or award may be made a rule of court, after which it becomes enforceable by writ of execution against person or property. An international award cannot be enforced directly; in other words, it has no legal sanction behind it. Its obligation rests on the good faith of the parties to the reference, and on the fact that public opinion can, with the help of a world-wide press, always be brought to bear on any state that may seek to evade its moral duty. The obligation of an ordinary treaty rests on precisely the same foundations. True it is that an international award may be disregarded for excess of jurisdiction, ambiguity of language, or corrupt conduct on the part of the arbitrator. But each of these flaws would be equally fatal to a private award. We have said that it is the duty of an international arbitrator to decide in accordance with international law. The eminent jurist, M. Bluntschli, considers that if he does not the award may be set aside. To admit this doctrine would, however, lead to endless disputes, since international law has never been codified. A fresh arbitration might have to be entered on in order to decide, first, what the law was, and, secondly, whether it applied to the matter in hand. As a matter of fact, there is but a single instance on record of an award being repudiated, viz., that of the king of Holland in 1831 with regard to the north-eastern boundary of the State of Maine. That case was, however, a very peculiar one. The arbitrator was unable to draw the frontier line by reason of the imperfection of the maps then extant, and his direction for a further topographical inquiry was beyond the terms of the reference. The award was, therefore, void for excess just as a private award would have been.

An account of this subject divides itself naturally into four parts: a brief sketch of past history; an examination of a few selected instances in which international arbitration has been successfully resorted to; an account of the various treaties and projects for securing its future employment; and a short discussion of the limits outside which it appears to be inapplicable.

History.

In the sense in which the term is now used, international arbitration is essentially a modern product, since the very existence of international relations is modern. The nearest approach to it before the Christian era was intermunicipal arbitration, as practised in ancient Greece. For example, the Amphictyonic Councils occasionally acted as arbitrators between one town and another; in this way a dispute was settled between Athens and Delos with regard to a right of precedence in the temple of Apollo in 344 B.C. The ancient Greek towns also sometimes referred their differences to a third town, or even to private individuals. Thus Sparta arbitrated between Athens and Megara with regard to the possession of Salamis; Periander between Athens and Mitylene with regard to the promontory of Sigeum; and Themistocles between Corinth and Corcyra with regard to the island or (as it formerly was) the peninsula of Leucadia. At the period of the Peloponnesian war, the practice of arbitration had become so well recognized that Thucydides (i. 85) puts into the mouth of Archidamus, king of Sparta, the words, "It is impossible to attack as a wrong-doer any one who is willing to answer before an arbitral tribunal." But in all these cases the arbitration was between two Hellenic communities. It would have been no more possible for a Greek to arbitrate with a "barbarian" than to sacrifice at the same altar with him.

The exclusiveness which checked the development of arbitration in Greece told against it with tenfold force in Rome.

Republican Rome dealt with non-Romans as modern European governments have dealt with inferior native races. When in 445 B.C. the Republic was chosen to arbitrate between the towns of Ardea and Aricia, she settled the question by taking the disputed land for herself. The same thing occurred in 180 B.C., when a territorial difference between Neapolis and Nola was referred to the Roman Senate. Under the Cæsars, frequent recourse was had to civil or private arbitration, the procedure of which was perfected by the best intellects of the day, but any other kind was from the nature of things impossible. The vastness of the territory of Imperial Rome was such that she had practically nothing external to herself. She proudly claimed to be "the arbiter of the universe," so that the notion of her arbitrating with an outside power involved a contradiction in terms.

The Middle Ages may not inaptly be characterized as a period of perpetual conflict—between absolutism and democracy, between great feudal lord and rebellious vassal, between Guelph and Ghibelline, between Catholic and Protestant. Amid this clash of arms the Popes were not infrequently appealed to, and there are several instances of their having acted either in that character or as mediators. Witness the intervention of Innocent III. between King John and his barons; of Boniface VIII. between Edward I. and Philippe le Bel; of Leo X. between Maximilian and the doge of Venice. A similar rôle was filled by the mediæval sovereigns, notably by the kings of France. In 1603 a scheme for establishing a General Council was projected by Sully, the minister of Henry IV., to which the fifteen states, into which Europe was to be parcelled out, were to submit all their differences. Needless to say, the scheme came to nothing. In truth, its object was not so much to establish an arbitration tribunal as to disestablish and disendow the House of Austria—a result which was reached after the Thirty Years' War, when northern Protestant Germany was severed from the Catholic monarchy of the south. A century after the publication of Sully's "Grand Design," a more disinterested and more elaborate scheme was prepared by the Abbé St. Pierre for settling all international disputes by means of a General League of Christendom. Rousseau says of it that it failed "because it was madness in its author to be wise when the majority of people were fools." However this may be, the seed sown by the good abbé, although it fell on barren ground, was not destined to perish. It produced a crop of other schemes later. Jeremy Bentham, in 1789, advocated the formation of a General Diet—or Congress—to which each of the powers should send two deputies, and he suggested making its decisions coercive by putting any refractory state under the ban of Europe. Immanuel Kant, in 1795, proposed to base all international right on a Federation of Free States, the civil constitution of each of which was to be made republican. Both Bentham and Kant were, indeed, as "voices crying in the wilderness," for Europe had no "ears to hear" after the war of the French Revolution had broken out and had deluged her in blood. Yet no sooner had that struggle ended than organized efforts on behalf of arbitration began to manifest themselves in various ways. The first of such efforts was made in 1816 by the Society of Friends in New York. In 1835 the American Peace Association presented a petition to the Senate of Massachusetts for establishing a "standing Court of Nations." Similar petitions were presented subsequently in Maine and Vermont. The subject was brought before the United States Senate in December 1837, and was referred to the Committee of Foreign Affairs, which reported it to be premature. In 1839 the same association presented a fresh petition for a similar purpose. This met with the same fate. In 1853 the United States Senate voted in favour of inserting arbitration clauses in treaties, "the arbitrators to be eminent jurists, having little or no connexion with politics." In 1849 Mr Richard Cobden advocated a similar proposition in the British House of Commons, and moved for an address to the Crown praying that the Queen would instruct her Foreign Secretary to see that it was carried out. He maintained that a treaty for general arbitration would be as binding as any other, and that a country which did not fulfil its obligation to refer would enter on war "with the brand of infamy stamped upon its banners." The motion for an address was opposed by Lord Palmerston, then first minister, who carried "the previous question" by a majority of 176 to 79. In 1873 Mr Henry Richard re-introduced the subject in a somewhat different form by urging an invitation to foreign powers to concur in a general and permanent system. In spite of much cold water thrown by Mr Gladstone, who had now become premier, Mr Richard obtained a majority of ten in his favour. The Representative Assembly at Westminster had thus, like the Senate at Washington, undergone a change of sentiment in the course of a single generation. Motions substantially similar to Cobden's were carried in the Italian Chamber in August 1873, in the Dutch Chamber in November 1874, in the Belgian Chamber in January 1875.

Almost contemporaneously with Mr Richard's success in Parliament, fresh impulse was given to the movement by bodies of public or learned men associated together, not for humanitarian purposes, but for the elucidation of international legal principles. The foremost of these was the Institute of International Law (*L'Institut de droit international*), which is composed of men of different nationalities, distinguished in that department of learning. Its first conference was held at Ghent on 18th September 1873, when a committee was appointed with special instructions to study the question. On this committee the United States were represented by Mr Dudley Field, Belgium by M. de Laveleye, Italy by Signor Pierantoni, Germany by Herr Goldschmidt, Great Britain by Sir William Vernon Harcourt (then Professor of International Law at Cambridge). In the same year there was founded in London an "Association for the Reform and Codification of the Law of Nations," which put international arbitration in the forefront of its programme. Its first meeting was held at Geneva in 1874. The name of this body was altered in 1895 to "The International Law Association." In 1888 a third association was formed under the style of "The Permanent Parliamentary Committee in favour of Arbitration and Peace," or, as it is sometimes called for shortness, "The International Parliamentary Union." This union has a permanent office at Berne. Its first meeting was held in Paris in June 1889, under the presidency of the late M. Jules Simon, and was attended by 129 members from England and the United States. In July 1890 the union met again in London under the presidency of the late Lord Herschell, and a committee was then formed to organize similar bodies on the Continent and in America. The meetings of the union continue to take place yearly.

The disputes which have been determined by international arbitration may be arranged in two main groups —A. Those which have arisen between state and state in their sovereign capacities; B. Those in which one state has made a demand upon another state, ostensibly in its sovereign capacity, but really on behalf of some individual or set of individuals whose interests it was bound to protect. To the former group belong territorial disputes, *e.g.*, questions of boundaries on land and of fisheries at sea; to the latter pecuniary claims in respect of acts alleged to have been wrongfully done to one or more subjects of one state by, or with the authority of, another state. Such acts comprise, amongst other things, (*a*) breaches of neutrality, by aiding and abetting a belligerent power or by permitting hostile operations to take place on neutral soil; (*b*) unlawful arrests and seizures. The remaining cases are of a miscellaneous character, and do not admit of separate classification.

San Juan.

(A.) "Territorial disputes," says Alexander Hamilton, the eminent American statesman, in the *Federalist*, "have at all times been found one of the most fertile sources of hostility among nations." "Perhaps," he adds, "the greatest portion of the wars that have desolated the earth have sprung from this origin." This sentiment, true enough at the close of the 18th century, is fortunately no longer correct. The settlement of territorial disputes by arbitration has of late been the rule rather than the exception. We begin with one which was a serious disappointment to Great Britain, having been marred by a mistake in the form of the reference, but in which, notwithstanding, she loyally acquiesced. The treaty of Washington of 1846 provided that the north-western frontier of the United States near the parallel of 49° N. should run in a westerly direction along that parallel to the middle of the channel which separates the continent from Vancouver Island, and thence in a southerly direction through the middle of the same channel and of Fuca Strait to the Pacific Ocean. The dispute was as to the precise way in which this southern line was to be drawn. It was referred to the German emperor to decide whether the line should pass through Rosario Strait or through the Canal de Haro. The emperor appointed a geographer, a jurist, and a diplomat to study the subject and to report to him. This they did, and on the 21st October 1872 he made an award by which the channel of Haro was divided equally between the contending parties, the United States being declared entitled to exclusive possession of all the other channels to the north of the Strait of Fuca, together with the island of San Juan and several small islets.

The facts of the territorial dispute between Great Britain and the Republic of Venezuela with regard to British Guiana—dating back to 1841 and not settled until 1899—are as follows:—

Venezuela.

The British claimed title through the Dutch, the Venezuelans claimed title through Spain. The Dutch in the course of their war of independence had established settlements along the coast of Guiana, of which the most important was Kijkoveral, situated at the point where the Cuyuni, the Massaruni, and the Essequibo rivers unite. In 1648, by the treaty of Munster, they were confirmed in the possession of the territory which they then held. Subsequently they extended their posts along the coast as far as the mouth of the Amakuru, and inland along the courses of the three rivers above named. The British claimed that their rights extended to the whole Cuyuni basin, but the boundary actually insisted upon was a line, laid out by Sir Robert Schomburgk in 1840, and known as the Schomburgk line, which included the district of Barima and so much of the basin of the Cuyuni as lies to the west of the main stream. This claim was based upon Dutch occupation, actual or constructive, of territory previously unoccupied. The Venezuelans claimed the whole country as far as the Essequibo, that is to say, more than half of the colony of British Guiana, as shown on the latest maps. They alleged that the bull of Alexander VI. of 1493 had granted to Spain all territory that she might discover west of a line drawn 100 leagues west of the Azores, and that at the date of the bull the papacy was universally recognized as a competent international authority, particularly in matters affecting territory reclaimed from the heathen. They further alleged that the Spaniards had discovered Guiana, and had thus obtained, even without the bull, an inchoate title, which they had perfected by exploration and acts of sovereignty.

In 1850 it was arranged between the two Governments that neither should enter into or encroach upon the territory in dispute; but subsequently the Venezuelans disregarded this arrangement, and in 1883-84 made grants and concessions in the territory claimed by the British. In November 1886 the British Government issued a notice to the effect that these concessions were invalid; and in consequence of this notice, and of other differences concerning the proposed erection of a lighthouse upon Barima Point, the Venezuelan Government in 1887 broke off diplomatic relations. In 1890 they suggested arbitration, which Great Britain refused on the ground that, as regarded the territory comprised within the Schomburgk line, the British title was clear and there was nothing to arbitrate about. In July 1895 Mr Secretary Olney, on behalf of the United States, addressed a lengthy despatch to the British Government, urging that the refusal to arbitrate should be reconsidered, and intimating that any attempt to put hostile pressure upon Venezuela would be considered by his Government as an infringement of the Monroe doctrine. To this Lord Salisbury replied that Great Britain could not consent to go to arbitration in respect of territory actually settled and occupied by British subjects. On 17th December President Cleveland, in his message to Congress, announced that Great Britain having refused arbitration, he intended to appoint a commission which should report upon the respective rights of the parties, and he added: "When such report is made and accepted, it will, in my opinion, be the duty of the United States to resist by every means in its power, as a wilful aggression upon its rights and interests, the appropriation by Great Britain of any lands, or the exercise of any governmental jurisdiction over any territory, which, after investigation, we shall have determined of right to belong to Venezuela." The effect of this message was to call forth in the United States a great display of warlike enthusiasm, and to occasion a fall in the value of American securities amounting to $100,000,000. In England it was received with considerable astonishment but without active resentment, the public mind being almost immediately diverted to the troubles arising out of Dr Jameson's raid into the Transvaal. In January 1896 the United States appointed their commission, and invited the British Government to furnish a statement of their case. The British Government declined to recognize the jurisdiction of this commission. Fresh negotiations were then entered into for arbitration, on the understanding that the rights of Great Britain in the settled territory should be protected. In February 1897 a treaty was signed at Washington between Great Britain and Venezuela, in which four arbitrators were named, viz., Lord Herschell and Sir Richard Henn Collins on behalf of Great Britain, and Chief-Justice Fuller and Mr Justice Brewer, both of the Supreme Court of the United States, on behalf of Venezuela. A fifth arbitrator was to be appointed by these four, or, in the event of their failure to agree, by the king of Sweden and Norway. The four arbitrators agreed to appoint as their colleague M. de Martens, privy councillor and member of the Ministry of Foreign Affairs in Russia. Lord Herschell having died in March 1899, the Lord Chief-Justice of England, Lord Russell of Killowen, was appointed in his place. The court so constituted assembled in Paris in June 1899. On 3rd October the arbitrators published their award. By it Venezuela obtained the district of Barima as far as Point Playa, and a strip of country between the Wenamu and Cuyuni rivers; elsewhere the new boundary coincided with the Schomburgk line. Barima, which is a district strategically important to Venezuela, but otherwise of little value, had been offered to her by the British Government at least three times in the prolonged course of the negotiation. The free navigation of the rivers Amakuru and Barima was secured to Great Britain, which had every reason to be satisfied with the result.

Newfoundland Fishery.

Of disputes with regard to fisheries, the two most important in recent times are the Newfoundland and the Bering Sea cases. The Newfoundland dispute is a very old one, and is not yet closed. By the treaty of Utrecht of 1713 a right was reserved to French subjects to catch fish and to dry them on that part of Newfoundland which stretches from Cape Bonavista to the northern point of the island, and from thence coming down by the western side reaches as far as Cape Riche. By the treaty of Versailles of 1783 France renounced the fishery from Bonavista to Cape St. John on the east coast, receiving in return extended rights upon the west coast as far as Cape Ray. Neither treaty purported to grant exclusive right, but there was annexed to the treaty of Versailles a declaration to the effect that "His Britannic Majesty will take the most positive measures for preventing his subjects from interrupting in any manner by their competition the fishery of the French during the temporary exercise of it which is granted to them upon the coasts of the island of Newfoundland, and he will for this purpose cause the fixed settlements which shall be formed there to be removed." Upon this declaration the French founded a claim to exclusive fishing rights within the limits named. Various conventions were entered into with a view to defining these rights in 1854, 1884, and 1885, but they remained inoperative, the consent of the Newfoundland Legislature—to which they were made subject—having been hitherto refused. Meanwhile the French Government granted a bounty to the French fishermen which enabled them to undersell the colonists. In 1887 the Newfoundland Legislature passed an Act forbidding the sale of bait, which struck a severe blow at the French industry. This was not, however, the whole cause of difference between Great Britain and France. At the date of the treaty of Utrecht, and for more than a century afterwards, the French fished in this region almost entirely for cod, but subsequently they also fished there for lobsters, and about the year 1886 they erected factories for "tinning" or "canning" lobsters at Port au Choix on the north-west coast of the island. This, it was contended, was not within the treaty, which only contemplated cod fishing, and gave no landing rights except in respect of that species of fish. Moreover, the colonial fishermen had, prior to 1886, erected lobster factories of their own on that part of the coast which is known as "the French shore," so that their trade was directly interfered with by the factories at Port au Choix. Mutual protests and remonstrances ensued, each party appealing to their respective governments to expel the intruders. At length, in March 1891, a treaty was signed between Great Britain and France by which the two nations agreed to refer the lobster dispute to a tribunal composed of three jurists named by the two countries in common, and four delegates, two from each country, who were to act as intermediaries between their respective governments and the other arbitrators. The arbitration tribunal had held no sitting down to the time of writing (1900), but a *modus vivendi* was arranged in 1890 by which no lobster fisheries which were not in operation in July of that year were to be permitted, except with the joint consent of the commanders of the British and French naval stations. This arrangement has been renewed from year to year, and has been the means of keeping the peace.

Another important fishery dispute arose between Great Britain and the United States with regard to the fur seals in Bering Strait. The facts are as follows:—

Bering Sea.

In the year 1867 the United States Government had purchased from Russia all her territorial rights in Alaska and the adjacent islands. The boundary between the two powers as laid down by the treaty for purchase was a line drawn from the middle of Bering Strait south-west to a point midway between the Aleutian and Komandorski Islands, dividing Bering Sea into two parts, of which the larger was on the American side of this line. This portion included the Pribyloff Islands, which are the principal breeding grounds of the seals frequenting those seas. By certain Acts of Congress, passed between 1868 and 1873, the killing of seals was prohibited upon the islands of the Pribyloff group and in "the waters adjacent thereto," except upon certain specified conditions. No definition of the meaning of the words "adjacent waters" was given in the Act. In 1870 the exclusive rights of killing seals upon these islands was leased by the United States to the Alaska Commercial Company, upon conditions limiting the numbers to be taken annually, and otherwise providing for their protection. As early as 1872 the operations of foreign sealers attracted the attention of the United States Government, but any precautions then taken seem to have been directed against the capture of seals on their way through the passages between the Aleutian Islands, and no claim to jurisdiction beyond the three-mile limit appears to have been put forward. On 12th March 1881, however, Mr French, acting secretary of the United States Treasury, in answer to a letter asking for an interpretation of the words "waters adjacent thereto" in the Acts of 1868 and 1873, stated that all the waters east of the boundary line were considered to be within the waters of Alaska territory. In March 1886 this letter was communicated to the San Francisco Customs by Mr Manning, secretary of the Treasury, for publication. In the same summer three British sealers, the *Carolena*, *Onward*, and *Thornton*, were captured by an American revenue cutter sixty miles from land. They were condemned by the district judge on the express ground that they had been sealing within the limits of Alaska territory. Diplomatic representations followed and an order for release was issued, but in 1887 further captures were made and were judicially supported upon the same grounds. The respective positions taken up by the two governments in the controversy which ensued may be thus indicated. The United States claimed as a matter of right an exclusive jurisdiction over the sealing industry in Bering Sea; they also contended that the protection of the fur seal was, upon grounds both of morality and interest, an international duty, and should be secured by international arrangement. The British Government repudiated the claim of right, but were willing to negotiate upon the question of international regulation. Between 1887 and 1890 negotiations were carried on between Russia, Great Britain, and the United States with a view to a joint convention. Unfortunately the parties were unable to agree as to the principles upon which regulation should be based. The negotiations were wrecked upon the question of pelagic sealing. The only seal nurseries were upon the Pribyloff Islands, which belonged to the United States, and the Komandorski group, which belonged to Russia. Consequently to prohibit pelagic sealing would have been to exclude Canada from the industry. The United States, nevertheless, insisted that such prohibition was indispensable on the grounds —(1) that pelagic sealing involved the destruction of breeding stock, because it was practically impossible to distinguish between the male and female seal when in the water; (2) that it was unnecessarily wasteful, inasmuch as a large proportion of the seals so killed were lost. On the other hand, it was contended by Great Britain that in all known cases the extermination of seals had been the result of operations upon land, and had never been caused by sealing exclusively pelagic. The negotiations came to nothing, and the United States fell back upon their claim of right. In June 1890 it was reported that certain American revenue cutters had been ordered to proceed to Bering Sea. Sir Julian Pauncefote, the British ambassador at Washington, having failed to obtain an assurance that British vessels would not be interfered with, laid a formal protest before the United States Government.

Thereupon followed a diplomatic controversy, in the course of which the United States developed the contentions which were afterwards laid before the tribunal of arbitration. The claim that Bering Sea was *mare clausum* was abandoned, but it was asserted that Russia had formerly exercised therein rights of exclusive jurisdiction which had passed to the United States, and they relied *inter alia* upon the ukase of 1821 by which foreign vessels had been forbidden to approach within 100 Italian miles of the coasts of Russian America. It was pointed out by Great Britain that this ukase had been the subject of protest both by Great Britain and the United States, and that by treaties similar in their terms, made between Russia and each of the protesting powers, Russia had agreed that their subjects should not be troubled or molested in navigating or fishing in any part of the Pacific Ocean. The American answer was that the Pacific Ocean did not include Bering Sea. They also claimed an interest in the fur seals, involving the right to protect them outside the three-mile limit. In August 1890 Lord Salisbury proposed that the question at issue should be submitted to arbitration. This was ultimately assented to by Mr Secretary Blaine on the understanding that certain specific points, which he indicated, should be laid before the arbitrators. On 29th February 1892 a definitive treaty was signed at Washington. Each power was to name two arbitrators, and the president of the French Republic, the king of Italy, the king of Norway and Sweden, were each to name one. The points submitted were as follows:—(1) What exclusive jurisdiction in the sea now known as Bering Sea, and what exclusive rights in the seal fisheries therein, did Russia assert and exercise prior, and up to the time of, the cession of Alaska to the United States? (2) How far were her claims of jurisdiction as to the seal fisheries recognised and conceded by Great Britain? (3) Was the body of water now known as Bering Sea included in the phrase "Pacific Ocean," as used in the treaty of 1825 between Great Britain and Russia, and what rights, if any, in Bering Sea were held exclusively exercised by Russia after the said treaty? (4) Did not all the rights of Russia as to jurisdiction and as to the seal fisheries in Bering Sea east of the water boundary, in the treaty between the United States and Russia of the 30th March 1867, pass unimpaired to the United States under that treaty? (5) Had the United States any and what right of protection over, or property in, the fur seals frequenting the islands of Bering Sea when such seals are found outside the three-mile limit? In the event of a determination in favour of Great Britain, the arbitrators were to determine what concurrent regulations were necessary for the preservation of the seals, and a joint commission was to be appointed by the two powers to assist them in the investigation of the facts of seal life. The question of damages was reserved for further discussion, but either party was to be at liberty to submit any question of fact to the arbitrators, and to ask for a finding thereon. The tribunal was to sit at Paris. The treaty was approved by the Senate on 29th March 1892, and ratified by the President on 22nd April.

The United States appointed as arbitrator Mr John H. Harlan, a Justice of the Supreme Court, and Mr John T. Morgan, a member of the Senate. The British arbitrators were Lord Hannen and Sir John Thompson. The neutral arbitrators were the Baron de Courcel, the Marquis Visconti Venosta, and Mr Gregers Gram, appointed respectively by the president of the French Republic, the king of Italy, and the king of Norway and Sweden. The sittings of the tribunal began in February and ended in August 1893. The main interest of the proceedings lies in the second of the two claims put forward on behalf of the United States. This claim cannot easily be stated in language of precision; it is indicated rather than formulated in the last of the five points specially submitted by the treaty. But its general character may be gathered from the arguments addressed to the tribunal. It was suggested that the seals had some of the characteristics of the domestic animals, and could therefore be the subject of something in the nature of a right of property. They were so far amenable to human control that it was possible to take their increase without destroying the stock. Sealing upon land was legitimate sealing; the United States being the owners of the land, the industry was a trust vested in them for the benefit of mankind. On the other hand, pelagic sealing, being a method of promiscuous slaughter, was illegitimate; it was *contra bonos mores* and analogous to piracy. Consequently the United States claimed a right to restrain such practices, both as proprietors of the seals and as proprietors and trustees of the legitimate industry. It is obvious that such a right was a novelty hitherto unrecognized by any system of law. Mr Carter, therefore, as counsel for the United States, submitted a theory of international jurisprudence which was equally novel. He argued that the determination of the tribunal must be grounded upon "the principles of right," that "by the rule or principle of right was meant a moral rule dictated by the general standard of justice upon which civilized nations are agreed," that "this international standard of justice is but another name for international law," that the particular recognized rules were but cases of the application of a more general rule, and that where the particular rules were silent the general rule applied. The practical effect of this contention appears to be that an international tribunal can make new law and apply it retrospectively. In spite of this ingenious argument, which was strenuously opposed by Sir Charles Russell, the leading counsel for Great Britain, the judgment of the arbitrators was in favour of Great Britain on all points. It only remained for the arbitrators to consider the question of regulation which had also been submitted to them. Upon this point the arguments of the American counsel were allowed their due weight. A close time was appointed for sealing, the use of firearms was forbidden in Bering Sea, and pelagic sealing was prohibited within sixty miles of the Pribyloff Islands. The award was signed and published on 15th August 1893. The question of damages which had been reserved was ultimately settled in 1897 by a joint commission appointed by the two powers in February 1896, the total amount awarded to the British sealers being $473,151.26.

(B.) We pass now to State action on behalf of individuals. The following is an illustration of a dispute of this class, which was settled by arbitration nearly forty years after the occasion which gave rise to it. On the night of 26th September 1814, during the war between Great Britain and the United States, the *General Armstrong*, an American privateer, fired upon the boats of a British squadron which had just entered the port of Fayal, an island of the Azores group. The British squadron retaliated next day by cannonading the privateer within the limits of the port, and managed to destroy her. Fayal and its port were then, as now, Portuguese territory, and the United States claimed to be indemnified by the Portuguese Government for the loss of the privateer, on the ground that the local authorities had committed a breach of neutrality in not interfering on her behalf when the British squadron opened fire. By treaty of 26th February 1851, it was agreed to submit this claim to arbitration, and Louis Napoleon, then president of the French Republic, was chosen arbitrator. It was proved that the governor of Fayal was aware on 27th February of what was going on, but it was also proved that his protection had not been invoked by the American skipper until after the firing had commenced, and that he then at once sent a remonstrance to the British captain requiring him to cease hostilities. It was further shown that the guns of the fort were insufficient to allow of an armed intervention by the Portuguese. In these circumstances the arbitrator, while recognizing the principle that a neutral power is bound to make compensation to a belligerent whose property has been lost or destroyed within the neutral jurisdiction by the hostile action of the opposite belligerent, by his award of 30th November 1852 absolved the Portuguese Government from blame (partly on the ground that the appeal to the local authorities was too late, and partly on the ground that the governor had no force sufficient to enable him to interfere with effect).

The "General Armstrong."

This arbitration had an interesting sequel. When the United States Government failed to obtain redress from the Portuguese, the owners of the privateer demanded it at the hands of their own Government, alleging that by espousing their cause in the arbitration proceedings the United States had admitted the claim against themselves. They succeeded in procuring both the House of Representatives and the Senate of the United States to pass a vote in their favour, but the claim was rejected by the Supreme Court on the grounds that it was bad, both in law and in morals. It is obvious that to have allowed it would have been to make a very awkward precedent. Governments would have to be very shy in future of arbitrating in such cases in the interests of private persons, if whenever the award proved adverse they were bound to compensate their clients out of the national exchequer.

A far more famous arbitration on breaches of neutrality took place twenty years afterwards between the United States and Great Britain. It is instructive both from the historical and the legal point of view, and is, therefore, worth stating at some length.

In 1861, as is well known, the southern states of North America seceded from the rest on the slavery question and set up a separate government under President Jefferson Davis. Hostilities began with the capture of Fort Sumter by the Confederates on 13th April 1861. On 19th April President Abraham Lincoln declared a blockade of the southern ports. On 14th May the British Government issued a proclamation of neutrality, by which the Confederates were recognized as belligerents. This example was followed shortly afterwards by France and other nations. The blockade of the southern ports was not at first effective, and blockade-running soon became an active industry. The Confederates established agencies in England for the purchase of arms, which they despatched in ordinary merchant vessels to the Bahamas, whence they were transhipped into fast steamers specially constructed for the purpose. But this was not all. In February 1862 they contracted for a gunboat, which they called the *Oreto*, to be built for them at Liverpool. Mr C. F. Adams, the United States Minister, having brought this circumstance to the notice of the British Government, an inquiry was ordered and the report was that the *Oreto* was a fast steamer, pierced for four guns and generally suitable for warlike purposes, but that she was destined for a firm in Palermo. This was enough to rouse suspicion, but no positive evidence was obtainable. On 22nd March the *Oreto* left Liverpool and was next heard of, not at Palermo, but at Nassau in the Bahamas. There she was seized by the Colonial Government, acting upon representations made by the British naval authorities. She was, however, released by the local courts on the ground that there was no conclusive evidence against her. She left Nassau in the company of a British-built ship, from which she received her armament at Green Kay, and entered the port of Mobile, whence she afterwards emerged under the name of the *Florida* as a fully equipped man-of-war commissioned by the Confederate Government. In October 1865 she was captured in Brazilian waters by a vessel of the United States.

The "Alabama."

The case of the *Alabama* was still more remarkable. In June 1862 this ship, originally known as "No. 290," was being built by Messrs Laird at Birkenhead. She was then nearly completed and was obviously intended for a man-of-war. On 23rd June Mr Adams forwarded to Earl Russell a letter from the United States Consul at Liverpool, giving certain particulars as to her character. This letter was laid before the law officers, who advised that, if these particulars were correct, the vessel ought to be detained. On 21st July sworn evidence, which was supplemented on 23rd July, was obtained and laid before the Commissioners of Customs (who were the proper authorities to enforce the provisions of the Foreign Enlistment Act of 1819), but they declined to move. On 23rd July the same evidence was laid before the law officers, who advised that there was sufficient ground for detention. By some accident, which has never been satisfactorily explained, but was probably connected with the severe illness of Sir John Harding, the Queen's Advocate, the papers were not returned till 29th July. Instructions were then issued to seize the vessel, but she had already sailed on the evening of the 28th. Although she remained for two days off the coast of Anglesey, there was no serious attempt at pursuit. She afterwards made her way to the Azores, where she received her armament, which was brought from Liverpool in two British ships. Captain Semmes there took command of her under a commission from the Confederate Government. After a most destructive career she was sunk off Cherbourg by the *Kearsarge* on 19th June 1864.

Another vessel, the *Sea King*, which had been employed as a merchant ship, left London in October 1864 and was met at Madeira by the *Laurel* from Liverpool with men, arms, and officers. Her name was then changed to *Shenandoah* and the Confederate flag was hoisted on board her. After a cruise of ninety days, during which she destroyed certain North American vessels, she put into Melbourne on 25th January 1865. In spite of the protest of the United States Consul she was allowed to remain till 18th February to effect repairs and to take on board considerable supplies of coal and provisions. She also contrived to enlist forty-five men. Some investigation was made by the colonial authorities, but they were satisfied with her captain's assurance that he had enlisted no one since her arrival. After a cruise in the Arctic Seas she returned to Liverpool in November 1865 and was afterwards handed over to the United States.

On these facts the United States Government alleged against Great Britain two grievances, or sets of grievances. The first was the recognition of the southern states as belligerents and a general manifestation of unfriendliness in other ways. The second was in respect of breaches of neutrality in allowing Confederate vessels to be built and equipped on British territory. Correspondence ensued extending over several years. At length in February 1871 a commission was appointed to sit at Washington in order, if possible, to arrive at some common understanding as to the mode in which the questions at issue might be settled. With respect to the *Alabama* claims the British commissioners suggested that they should be submitted to arbitration. The

American commissioners refused "unless the principles which should govern the arbitrators in the consideration of the facts could be first agreed upon." After some discussion the British commissioners consented that the three following rules should apply. A neutral government is bound—(1) to use due diligence to prevent the fitting out, arming, or equipping within its jurisdiction of any vessel, which it has reasonable ground to believe is intended to cruise or to carry on war against a power with which it is at peace, and also to use like diligence to prevent the departure from its jurisdiction of any vessel intended to cruise or carry on war as above, such vessel having been specially adapted, in whole or in part, within such jurisdiction, to warlike use; (2) not to permit or suffer either belligerent to make use of its ports or waters as the base of naval operations against the other, or for the purpose of the renewal or augmentation of military supplies or arms or the recruitment of men; (3) to exercise due diligence in its own ports and waters, and as to all persons within its jurisdiction to prevent any violation of the foregoing obligation and duties. The arrangements made by the commission were embodied in the treaty of Washington, which was signed on 8th May 1871, and approved by the Senate on 24th May. Article 1, after expressing the regret felt by Her Majesty's Government for the escape, in whatever circumstances, of the *Alabama* and other vessels from British ports, and for the depredations committed by these vessels, provided that "the claims growing out of the acts of the said vessels, and generically known as the *Alabama* claims" should be referred to a tribunal composed of five arbitrators, one to be named by each of the contracting parties and the remaining three by the king of Italy, the president of the Swiss Confederation, and the emperor of Brazil respectively. By Article 2 all questions submitted were to be decided by a majority of the arbitrators, and each of the contracting parties was to name one person to attend as agent. Article 6 provided that the arbitrators should be governed by the three rules quoted above, and by such principles of international law not inconsistent therewith as the arbitrators should determine to be applicable to the case. By the same article the parties agreed to observe these rules as between themselves in future, and to bring them to the knowledge of other maritime powers. Article 7 provided that the decision should be made within three months from the close of the argument, and gave power to the arbitrators to award a sum in gross in the event of Great Britain being adjudged to be in the wrong.

The treaty was, on the whole, welcomed in England. The United States appointed Mr C. F. Adams as arbitrator, and Mr J. C. Bancroft Davis as agent. The British Government appointed Sir Alexander Cockburn as arbitrator, and Lord Tenterden as agent. The arbitrators appointed by the three neutral powers were Count Sclopis (Italy), M. Staempfli (Switzerland), Baron d'Itajuba (Brazil). The first meeting of the tribunal took place on 15th December 1871 in the Hôtel de Ville, Geneva. As soon as the cases had been formally presented, the tribunal adjourned till the following June. There followed immediately a controversy which threatened the collapse of the arbitration. It was found that in the American case damages were claimed not only for the property destroyed by the Confederate cruisers, but in respect of certain other matters known as "indirect losses," viz., the transference of the American marine to the British flag, the enhanced payments of insurance, the expenses of pursuit, and the prolongation of the war. But this was not all. The American case revived the charges of "insincere neutrality" and "veiled hostility" which had figured in the diplomatic correspondence, and had been repudiated by Great Britain. It dwelt at length upon such topics as the premature recognition of belligerency, the unfriendly utterances of British politicians, and the material assistance afforded to the Confederates by British traders. The inclusion of the indirect losses, and the other matters just referred to, caused great excitement in England. That they were within the treaty was disputed, and it was urged that, if they were, the treaty should be amended or denounced. In October 1872 Lord Granville notified to General Schenck, the United States Minister, that the British Government did not consider that the indirect losses were within the submission, and in April the British counter-case was filed without prejudice to this contention. On the 15th of June the tribunal reassembled and the American argument was filed. The British agent then applied for an adjournment of eight months, ostensibly in order that the two governments might conclude a supplemental convention, it having been meanwhile privately arranged between the arbitrators that an extra-judicial declaration should be obtained from the arbitrators on the subject of the direct claims. On 19th June Count Sclopis intimated on behalf of all his colleagues that, without intending to express any opinion upon the interpretation of the treaty, they had arrived at the conclusion that "the indirect claims did not constitute upon the principles of international law applicable to such cases a good foundation for an award or computation of damages between nations." In consequence of this intimation Mr Bancroft Davis informed the tribunal on 25th June that he was instructed not to press those claims; and accordingly on 27th June Lord Tenterden withdrew his application for an adjournment, and the arbitration was allowed to proceed. The discussion turned mainly on the question of the measure of "due diligence." The United States contended that it must be a diligence commensurate with the emergency or with the magnitude of the results of negligence. The British Government maintained that while the measure of care which a government is bound to use in such cases must be dependent more or less upon circumstances, it would be unreasonable to require that it should exceed that which the governments of civilized states were accustomed to employ in matters concerning their own security or that of their citizens. The tribunal adopted the view suggested by the United States. The vessels complained of were the *Florida* and her tenders the *Clarence*, *Tacony*, and *Archer*; the *Alabama* and her tender the *Tuscaloosa*; the *Shenandoah*; the *Georgia*, the *Sumter*, the *Nashville*, the *Tallahassee*, the *Chickamauga*, the *Sallie*, the *Jefferson Davis*, the *Music*, the *Boston*, and the *V. H. Joy*. The tribunal found that Great Britain was responsible for all the depredations of the *Florida* and *Alabama*, and for those committed by the *Shenandoah* after she left Melbourne. In the case of the *Alabama* the court was unanimous; in the case of the *Florida* Sir A. Cockburn alone, and in the case of the *Shenandoah* both he and Baron d'Itajuba dissented from the majority. The tenders were held to follow in each case the fate of their principals. In the cases of the other vessels the judgment was in favour of Great Britain. The tribunal decided to award a sum in gross, and (Sir A. Cockburn again dissenting) fixed the damages at $15,500,000. On 14th September the award was formally published and signed by all the arbitrators except Sir A. Cockburn, who filed a lengthy statement of his reasons. This document contained an elaborate reply to certain attacks which had been made upon the good faith of the British Government—attacks which had better have been left unnoticed. They formed no part of the issue; and if they were to be refuted that task was for the British counsel, not for the British arbitrator.

The stipulation that the three rules should be jointly submitted by the two powers to foreign nations has never been carried out. For this the British Government has been blamed by some. But there appears to have been a general impression upon both sides, as well as among Continental publicists, that the language of the rules was not sufficiently precise to admit of their being generally accepted as a canon of neutral obligations.

H.M.S. "Forte."

Of instances of arbitration on unlawful arrests and seizures we may specially note the following. On 7th June 1863 three officers of a British ship, the *Forte*, stationed on the coast of Rio Janeiro had a fracas with a Brazilian sentinel, and were in consequence arrested by the police and lodged in prison. This being notified to the British Consul, he explained to the authorities who the prisoners were, whereupon they were at once liberated. The British Government took up the matter and demanded redress from the Brazilian Government. The dispute threatened to be serious. It was referred, by consent, to the arbitration of the king of Belgium, who pronounced against the officers, on the ground that as they were not in uniform when arrested, no insult to the British Navy could possibly have been intended.

Butterfield claim.

In September 1854 the steamer *Benjamin Franklin* and the barque *Catherine Augusta*, both the property of Carlos Butterfield and Co., cleared at New York for the port of St. Thomas in the Danish West Indies. The *Catherine Augusta* was laden with cannon and other war material. At that time revolution was supposed to be imminent in Venezuela, and there were grounds for suspecting that these two vessels were destined to aid the insurgents. On the voyage the *Catherine Augusta* was much damaged by a storm, so that it became necessary for her to land her cargo for repairs. The Danish governor, who had received a communication from Venezuela, insisted on her giving, as a condition of her landing, security to the extent of $20,000 that no breach of the neutrality of the port was intended. To this the owners were compelled to agree. The original expedition, whatever its design, appears to have been abandoned, since the two vessels remained in the port awaiting the event of some negotiations for their sale to Mexico. In the meanwhile the *Benjamin Franklin* had been chartered by the Royal British Mail Steamship Company for a voyage to Barbadoes and back. She neglected to provide herself before starting with the permit required by the local regulations, and was accordingly fired at from one of the Danish forts. One shot struck her, but did little injury, and her voyage was only delayed a day. In 1860 Mr Secretary Cass brought to the notice of the Danish Government a claim by Carlos Butterfield and Company in respect of the detention of the two ships and of the firing into the *Benjamin Franklin*. After protracted negotiations, the matter was ultimately referred to Sir Edmund Monson, then British Minister at Athens. He made his award on 22nd January 1890, and decided that both claims were unfounded.

The "Costa Rica Packet."

In 1888 a Dutch craft, the property of an Amboynese firm, drifted from her moorings in the Malay archipelago and was carried to the island of Buru, no one being on board at the time. Shortly afterwards the owners were informed that she had been taken possession of by a whaling-vessel called the *Costa Rica Packet* (John Carpenter, a British subject, being master), then on its way from New South Wales, and that Carpenter had transferred the cargo to his own ship and had sold it at Batchian. A complaint was at once lodged against the master before the officials at Macassar, and they, considering that a *prima facie* case against the master had been made out, issued a warrant for his arrest. Accordingly, on the arrival of the *Packet* at Ternate, Carpenter was seized and brought to Macassar to be tried—his ship proceeding to Batavia without him. When the facts came to be further inquired into at Macassar, it became evident that the wrongful appropriation, if any such there had been, had taken place on the high seas, more than three miles from land. The court therefore held, in conformity with the well-known rule, that it had no jurisdiction to interfere, Carpenter being answerable for his acts to the British Government alone. It therefore ordered his discharge. It was now Carpenter's turn to complain. When he was set free the Batavian mail had just left Macassar; he was consequently forced to remain there over three weeks, and when at last he reached Batavia, it was too late to take advantage of the whaling season in the southern seas. The *Packet* being useless except as a whaling-vessel had to be sold at Singapore at a loss. Heavy damages were claimed against the Netherlands Government by all the parties interested, and a correspondence ensued between that Government and the British which extended over four years. At length, in May 1895, both Governments signed an arbitration treaty by which they agreed to invite a third power to nominate a jurist of undoubted reputation who should settle the points in difference. The power chosen was Russia, and the Emperor Nicholas II. nominated, as arbitrator, Professor F. de Martens. He, by his award in 1897, declared the Netherlands Government liable to pay £8550, distributed as follows:—£3800 to the owners of the *Packet*; £3150 to Carpenter; £1600 to the remaining officers and the crew; each of these amounts to carry interest at 5 per cent. as from the date of Carpenter's arrest.

The latest arbitration on illegal seizure is that known as the Delagoa Bay Railway case, of which the facts are as follows:—

Delagoa Railway.

In December 1883 the Portuguese Government granted to Colonel M'Murdo, an American citizen, a concession for the construction and working during ninety-nine years of a railway from Lorenzo Marques, the port of Delagoa Bay, to the frontier of the Transvaal. It was a term of the concession that the Portuguese Government should not construct or allow within the district of Lorenzo Marques any other railway from the coast to the Transvaal parallel to the M'Murdo line within a distance of sixty miles. It was further provided that the concessionaire should have the absolute right of fixing the charges both for passengers and goods. In furtherance of his scheme Colonel M'Murdo formed a Portuguese company, but this company being unable to raise sufficient capital delegated its powers and transferred the bulk of its property to an English company, formed in March 1887 and called "The Delagoa Bay and East African Railway (Limited)." The last-named company issued shares and bonds which were largely taken up by Colonel M'Murdo and by English investors. Before the grant of the concession of 1883 an agreement had been made between the South African Republic and Portugal whereby the former bound itself, whenever the Delagoa Bay Railway should reach the Transvaal frontier, to continue the line as far as Pretoria. At this period the frontier of the Transvaal had not been finally delimited, but the Portuguese officials placed it in their maps at about 80 kilometres from the coast. The Portuguese Government agreed that, if this distance was increased, the company which had undertaken to make the railway to the frontier should be allowed a reasonable extension of time. On 17th May 1884 the Portuguese Government promised to the Transvaal Government a concession for a steam tramway parallel to the projected railway in case the English company failed to complete the railway by the prescribed date, and also promised that the steam tramway should be used both for passengers and goods if the Portuguese Government failed to agree with the English company as to the through rates to be charged on the railway. This promise was embodied in a commercial treaty negotiated by President Kruger (who made a special visit to Lisbon for the purpose), and was kept secret from Colonel M'Murdo and the shareholders and creditors of the English company. The frontier line of the Transvaal was ultimately drawn through Komati Poort, a point about five miles farther from the coast than that shown on the Portuguese maps. The Portuguese Government thereupon required that the railway from Lorenzo Marques should be continued up to the new frontier, eight extra months (of which five were in the rainy season) being allowed for the extension. This was an unreasonable term, and was not, and could not be, complied with. At the end of the eight months the Portuguese Government declared Colonel M'Murdo's concession forfeited, and seized the nearly completed railway.

The Governments of Great Britain and the United States remonstrated in the interest of the widow of Colonel M'Murdo and the other creditors of the English company, the British Government going so far as to despatch a gunboat to Delagoa Bay and threaten to back its remonstrance by force. Here in truth was a *casus belli* with Portugal, for that country appeared to have broken its pledges under pressure from, and in deference to the political aims of, the South African Republic. Happily pacific counsels prevailed. An agreement was come to between Great Britain, the United States, and Portugal, whereby it was referred to arbitrators to be named by the Federal Council of Switzerland to determine the compensation to be paid by Portugal to the parties interested in the forfeited undertaking, the illegality of the proceedings of the Portuguese Government being admitted by the form of the reference. The subsequent dates are remarkable. The arbitrators were named in 1890, and in that year Portugal paid £28,000 on account. The court began to sit at Berne in 1892; the pleadings closed in 1896. It was then decided to appoint a commission of experts to make local inquiries and to report. When the report came in, the sittings were resumed, and were not concluded until the summer of 1898. The award (which was unanimous) was published on 29th March 1900. It directed Portugal to pay to the Governments of Great Britain and the United States within six months from the publication of the award the sum of £612,500 (in addition to the £28,000 paid in 1890), together with interest at 5 per cent. per annum from 25th June 1889 down to the time of payment, making a total of nearly £1,000,000 sterling. This sum was to be employed in compensating the bond-holders and other creditors of the Delagoa Bay Railway Company according to their several priorities, such priorities to be settled by arrangement between the claimants themselves. The costs of the arbitration were to be borne equally by the three governments, that is to say, one-third by each.

Closely akin to international arbitration is the proceeding by Mixed Commission, on which all the parties in difference are represented. Such commissions have been most frequently resorted to for settling the indemnities to

Mixed commissions.

be paid to non-combatants in respect of losses occasioned by war. Amongst the earliest of these commissions was that appointed under the treaty of 19th November 1794, negotiated with Lord Grenville by Mr John Jay, the distinguished American lawyer and statesman, and known as "The Jay Treaty," the object of which was to settle the indemnities to be paid by Great Britain and the United States respectively to owners of merchant ships captured during the American revolutionary war. Similar commissions were appointed in pursuance of the treaty of Vienna of 20th November 1815. In 1843, wholesale claims for indemnity were settled by a mixed commission after certain preliminary points had been decided by arbitration in the following circumstances. France had found it necessary to take punitive measures against certain Moorish tribes on the West Coast of Africa in order to protect her colonies at Senegal from the arbitrary exactions by which they were oppressed. With this view she blockaded the coast of Portendic, but failed to notify the fact to the owners of the British vessels who traded with the nations in gum and other exports. The result was that the commercial arrangements of the British owners were upset and they claimed compensation at the hands of their Government. Correspondence on the subject with the French Government went on for four years. It was finally agreed to refer to the king of Prussia the determination of two questions, one of fact, the other of law. (1) Did the blockade occasion losses to the British traders in the exercise of their lawful calling? (2) If yea, was France bound to make these losses good? The king

TABLE I.

Territorial Disputes.

Date of Agreement to refer.	Parties.	Arbitrating Authority.	Subject Matter.	Result.
24th Dec. 1814 (Treaty of Ghent)	Great Britain and United States	Mixed commission	Islands in Passamaquoddy Bay near the mouth of the St Croix river	24th Nov. 1817.—Dispute settled
Do.	Do.	Do.	Northern boundary of U.S.	18th June 1822.—Delimitation effected
29th Sept. 1827	Do.	King of the Netherlands	North-east boundary of U.S.	9th Aug. 1842.—Award not accepted by U.S., but dispute settled by Webster-Ashburton Treaty
13th Jan. 1868	Great Britain and Portugal	General Ulysses S. Grant, President of U.S.	Sovereignty over island of Bulama, off west coast of Africa	21st April 1870.—In favour of Portugal
1871	Great Britain and United States	Mixed commission	Nova Scotia fisheries	23rd Nov. 1871.—$5,500,000 awarded to Great Britain, the American commissioners dissenting. Congress, however, voted the full amount
Sept. 1872	Great Britain and Portugal	President of French Republic	Territories and islands in Delagoa Bay	24th July 1875.—In favour of Portugal
31st Dec. 1873	Italy and Switzerland	Mixed commission	Boundary between Italy and Canton of Ticino	23rd Sept. 1874.—In favour of Italy
1874	Persia and Afghanistan	Generals Goldsmid and R. Pollock (British officers)	Boundaries on north-west frontier of India	Delimitation effected
3rd Feb. 1878	Argentine Republic and Paraguay	President of United States	Frontier dispute	12th Nov. 1878.—In favour of Paraguay
1878	Argentine Republic and Chile	Ministers of U.S. in the two countries	Strait of Magellan and land boundaries	Sept. 1881.—Delimitation effected
13th July 1878 (Treaty of Berlin)	Turkey and Greece	Representatives of Great Britain, France, Germany, Austria, Russia	Territorial sovereignty	1st July 1880.—Thessaly and part of Epirus to be ceded to Greece. Decision embodied in treaty of 14th June 1881
14th Sept. 1881	Colombia and Venezuela	King Alfonso XII. of Spain, and on his death the Queen Regent Christine	Boundary dispute	May 1891.—In favour of Colombia
10th Sept. 1885	Great Britain and Russia	Mixed Commission	Afghan boundary	21st May 1886.—Delimitation effected
24th Dec. 1886	Nicaragua and Costa Rica	President Cleveland	Right of navigation in San Juan river, &c.	21st March 1888.—Mainly in favour of Costa Rica
1st Aug. 1887	Peru and Ecuador	King of Spain, and on his death the Queen Regent	Territory east of Rio Bamba	Delimitation effected
29th Nov. 1888	France and Holland	Emperor of Russia	Boundaries of French and Dutch Guiana	25th May 1891.—In favour of Holland
Jan. 1891	Persia and Afghanistan	Viceroy of India	Frontier of the Heshtadan district	Delimitation effected
1893	Great Britain, Russia, and Afghanistan	Anglo-Russian commission	Use of waters of river Kushk	Dispute settled
1897	France and Germany	Mixed commission	Hinterland of Togo, Gold Coast of Africa	11th July 1897.—Dispute settled
April 1897	France and Brazil	Federal Council of Switzerland	Boundary between Brazil and French Guiana	1st Dec. 1900.—Awarded to Brazil 147,000 square miles of the disputed territory to the Araguay river on the S. and France about 3000 square miles to the N. of the Tumuc Humac mountains. Practically in favour of Brazil
12th Nov. 1898	Argentine Republic, Chile, and Bolivia	Mixed commission	Boundary of the province of Atacama	25th March 1899.—Delimitation effected

of Prussia decided both questions in the affirmative. A mixed commission was then appointed to assess the damages to be paid to the traders. They were fixed at 41,770 francs 89 centimes. The precision of these figures shows that the indemnity was for actual losses sustained and proved, and not, as in the *Alabama* case, a round sum awarded, as between state and state, to satisfy claims to be ascertained thereafter. Another mixed commission with very extensive powers was appointed under the treaty of Washington of 15th January 1880 between the

TABLE II.

Claims in respect of Seizures and Arrests.

Date of Agreement to refer.	Parties.	Arbitrating Authority.	Subject Matter.	Result.
14th Feb. 1851	France and Spain	King of the Netherlands	Claims and cross-claims in respect of seizures of vessels in 1823-24	Claims adjusted
1864	Great Britain and Peru	Senate of Hamburg	Imprisonment by Peru of Capt. T. Melville White, a British subject	Claim disallowed
16th June 1870	United States and Spain	Mixed commission	Seizure of American s.s. *Colonel Lloyd Aspinwall*	15th Nov. 1870.—$19,170,250 awarded to U.S.
1872	Japan and Peru	Emperor of Russia	Seizure of Peruvian barque *Maria Luz*	17th May 1875.—In favour of Japan
17th Aug. 1874	United States and Colombia	Mixed commission	Seizure of American s.s. *Montijo* by insurgents of Panama	27th June 1885.—$33,401 awarded to U.S.
15th Oct. 1879	France and Nicaragua	French court of cassation	Seizure of French ship *Le Phare*	29th July 1880.—40,320 francs awarded to France
26th March 1881	The Netherlands and Hayti	President of French Republic	Seizure of Dutch ship *The Havana Packet*	16th March 1883.—140,000 francs awarded to the Netherlands
28th Feb. 1885	United States and Spain	Italian minister at Madrid	Seizure of American s.s. *The Masonic* at Manila	27th June 1885.—$5,167,407 awarded to U.S.
28th Feb. 1893	United States and Ecuador	British minister at Quito	Arrest of an American citizen at Quito	In favour of U.S.
1896	Great Britain and Belgium	President of French court of cassation	Arrest of Mr Ben. Tillett, a British subject	Jan. 1899.—In favour of Belgium

TABLE III.

Miscellaneous Claims for Damages.

Date of Agreement to refer.	Parties.	Arbitrating Authority.	Subject Matter.	Result.
20th Oct. 1818	Great Britain and United States	Emperor of Russia	Obligation to restore slaves in possession of the British	21st April 1822.—In favour of U.S.
11th April 1839	United States and Mexico	King of Prussia	Losses of U.S. citizens during war between France and Mexico	Claims only partially settled, and war between U.S. and Mexico in 1846
18th July 1850	Great Britain and Greece	Mixed commission	Losses of British subjects during riots in Athens	Claims settled, the most remarkable being that of Don Pacifico, a native of Gibraltar, and therefore a British subject, who demanded £21,295 and was awarded £150 only
10th Nov. 1858	United States and Chile	King of the Belgians	Seizure of specie on board the U.S. brig *Macedonian* by Lord Cochrane, then admiral of Chilian fleet	18th May 1863.—Chile to refund three-fifths of the value of the specie with interest
15th July 1864	Great Britain and Argentine Republic	President of Chile	Losses arising out of decree of Argentine Government prohibiting vessels from Monte Video to enter Argentine ports	1st Aug. 1870.—In favour of Argentine Republic
14th March 1870	United States and Brazil	British Minister at Washington	Loss of whale-ship *Canada*	11th July 1870.—$10,070,494 awarded to U.S.
1873	Great Britain and Brazil	Envoys of U.S. and Brazil at Rio de Janeiro	Claims by earl of Dundonald in respect of services rendered by his father, Admiral Cochrane, to Brazil during her war of independence	8th Oct. 1873.—£38,175 awarded to Earl Dundonald
23rd July 1873	Great Britain and France	Mixed commission	Duties levied in France on mineral oils	5th Jan. 1874.—314,393 francs awarded to British claimants
1874	China and Japan	British minister at Peking	Murder of Japanese citizens by Chinese in islands of Formosa	500,000 taels awarded to Japan
24th May 1884	United States and Brazil	Hon. Wm. Strong, ex-judge of the supreme court of U.S.	Claims in respect of law proceedings in Hayti against two American citizens	14th June 1885.—In favour of U.S., but award not enforced
24th Feb. 1891	France and Venezuela	President of Swiss Confederation	Claim by French contractor in respect of a judgment obtained by him in Venezuelan courts, of which execution was refused by the executive	30th Dec. 1896.—4,346,656 francs awarded to French plaintiff

United States and France. This treaty dealt both with claims and counterclaims, namely—(1) claims by American citizens against the French Government for damages sustained by them during the last war between France and Mexico, or during that of 1870-71 between France and Germany, or during the insurrection of the Commune; (2) counterclaims by French citizens against the United States Government for damages sustained at the hands of American citizens during the War of Secession of 1861-65. The commission was composed of three persons, one named by the French Government, one by the president of the United States, and the third by the emperor of Brazil. The losses sustained by French subjects during the war between Chile and Peru were ascertained in the same manner in pursuance of a treaty of 2nd November 1862. Examples of similar commissions might be easily multiplied, but the practice is too well established to make it worth while to particularize them here.

A large number of international differences, without reckoning those already specially noted or the war-indemnity claims just referred to, have been adjusted, or put in trim for adjustment, either by arbitration or by mixed commissions, since the pacification of 1815. The majority of these cases are summarized in the preceding tables, which have been compiled in part from the volumes of Professor Moore and in part from Dr Evans Darby's revised list, respectively mentioned at the end of this article.

General conventions.

Up to this point we have only dealt with arbitrations on what may be termed specific differences. There are, however, in existence several conventions which provide for the settlement by international arbitration not merely of specific differences, but of all differences, present and future, which may arise between the contracting parties as regards certain subjects, *e.g.*, commerce or navigation. Clauses to this effect (*clauses compromissoires*) have been agreed to since 1862 between Great Britain on the one hand, and Italy, Greece, Portugal, Mexico, Uruguay respectively on the other hand; between Belgium on the one hand, and Italy, Greece, Sweden, Norway, and Denmark respectively on the other hand; between France and Korea; between Italy and Montenegro; between Austria-Hungary and Siam; between Spain and Sweden and Norway; between Denmark and Venezuela; between the Netherlands and Rumania; between Japan and Siam. The conventions of the Postal Union of 1874 and 1891, and of 1890 for the international transport of goods by rail, are instances of the same class. There are also in existence conventions for settlement by international arbitration of all differences without exception. Such are the treaties of Guadalupe-Hidalgo of 1848 between the United States and Mexico; of Belgium with Hawaii and Siam in 1862 and 1868 respectively; with Venezuela in 1884, and Ecuador in 1887; of 1888 between Switzerland and San Salvador and Ecuador; and of 1894 between Spain on the one hand, and Honduras and Colombia on the other.

So much has been actually accomplished. Other schemes for general arbitration have been mooted and carried to a certain point, although they have not yet been realized. When, in December 1882, President Garfield announced in his annual message his willingness to assist any measure which might tend to secure peace, the Swiss Government responded by offering to agree to a general arbitration treaty with the United States. A draft treaty was accordingly prepared, and submitted to the Swiss Federal Council, which adopted it on 24th July 1883; but owing to the death of Mr Secretary Frelinghuysen, who had been the principal American negotiator, the project fell through. A similar proposal was brought forward at the Inter-American Congress held at Washington 1889-90, which was attended by delegates from the United States and seventeen Republics of Central and South America. It took the form of a solemn recommendation by the delegates to their respective governments "to adopt arbitration as a principle of American international law for the settlement of the differences, disputes, or controversies that might arise between two or more of them." A treaty to this effect was signed by delegates from the United States and also from Guatemala, Honduras, Nicaragua, San Salvador, Venezuela, Ecuador, Brazil, and Bolivia, but was not ratified by the governments named in it within the prescribed time. An attempt to revive it was made by the smaller states in 1891 but without success.

In 1896 an effort was made by the representatives of Great Britain and the United States to provide for the submission to arbitration of "all questions in difference between those countries which might fail to adjust themselves by diplomatic negotiations." A treaty to this effect was prepared and signed on 11th January 1897 by the British ambassador (Sir Julian Pauncefote) and Mr Secretary Olney. It presented three forms of procedure, one for pecuniary claims or groups of pecuniary claims which did not in the aggregate exceed £100,000; a second for pecuniary claims beyond that amount, and a third for territorial claims, including rights of navigation and of access to fisheries. For the settlement of the first set of claims, each of the contracting parties was to nominate one arbitrator who was to be a jurist of repute, and the two arbitrators so nominated were to select a third, who was to be the president of the tribunal. The award of the majority was to be final. The second set of claims was to be referred to a tribunal similarly constituted, but in this case the award was only to be final if the tribunal was unanimous. If not unanimous, either of the contracting parties might demand a review of the award within six months from its date. In such case, the matter in controversy was to be submitted to a tribunal consisting of five jurists, no one of whom was to be a member of the original tribunal whose award was to be reviewed. The five jurists were to be nominated as follows:—two by each of the contracting parties, and one to act as umpire by the four thus nominated. The award of the majority of the members was to be final. The third set of claims (territorial) was to be submitted to a tribunal composed of six members, three of whom, subject to a particular exception, were to be judges of the Supreme Court of the United States or justices of Circuit Courts to be nominated by the president of the United States, the other three being judges of the British Supreme Court of Judicature or members of the Judicial Committee of the Privy Council nominated by the British Crown. The award in this case was to be final if made by a majority of five to one. In the event of its being less than five to one, it was not to be binding if protested against by either party within three months of publication. If so protested against, or if there was no award by reason of the numbers being equally balanced, there was to be no recourse to hostile measures of any description until the mediation of one or more friendly powers had been invited by one of the contracting parties. In spite of the elaborate care and caution with which this treaty was drawn, it remains a dead letter for want of ratification by the respective governments on whose behalf it was signed. It may be that its very elaborateness has proved a bar to its success, just as a parade of too many safety appliances on the eve of a mountaineering expedition is apt to unbrace our nerves and enhance our sense of danger.

Hague Conference.

The plan of establishing a standing arbitration tribunal advocated by Jeremy Bentham has been already referred to. In 1838 the New York Peace Society proposed to establish a Board of International Arbitration, and the idea was further worked out in 1842 by James Mill. Subsequently Mr Dudley Field in America, Dr Goldschmidt in Germany, Sir Edmund Hornby and Mr Leone Levi in England, successively produced draft rules of procedure by which, unless otherwise agreed, the permanent court was to be bound. Dr Goldschmidt's rules were revised and adopted by the Institute of International Law in 1875, and again considered by the Inter-Parliamentary Conference held at Brussels in 1895. All these efforts, however, excellent as they were in their generation, have been thrown into the shade by the work of the Peace Conference initiated in 1898 by the emperor of Russia, and held at the Hague in the following year. On 24th August 1898 Count Muravieff handed to all the foreign representatives accredited to the court of St. Petersburg a circular informing them that the Tsar proposed to their respective governments the holding of a Conference "which should occupy itself with the grave question of the excessive armaments which weighed upon all nations with a view of putting an end to their progressive development." This circular was shortly followed by another setting forth a preliminary draft programme for the Conference, which embraced not only the reduction of armaments and the more humane conduct of warfare, but also "the employment of good offices of mediation and arbitration in cases lending themselves thereto." The Conference met on 18th May 1899 at the Hague, and was attended by delegates from nineteen states under the presidency of Baron de Staal, the Russian ambassador at London. Other well-known delegates were Sir Julian Pauncefote (afterwards Lord Pauncefote), British ambassador at Washington; Mr Seth Low, president of Columbia University, New York; M. Leon Bourgeois, ex-premier of France, Count Munster, German ambassador at Paris. The Conference was divided into two sections, the province of the first being to deal with the limitation of armaments; of the second, with the laws of warfare; of the third, with mediation and arbitration. At one of the early sittings of the third section (over which M. Bourgeois presided), Baron de Staal produced a draft convention for rendering arbitration compulsory in certain cases and optional in others. Under the compulsory class were ranged disputes relating to pecuniary damages sustained by a state owing to the illegal or negligent action of another state—disputes relating to the interpretation of postal, telegraph, and railway conventions, of conventions relating to the navigation of international rivers, and divers other matters. To this convention (officially described as the "Russian project") was appended a draft code of procedure closely resembling that under which the Venezuelan arbitration was at that moment being conducted in Paris. Sir Julian Pauncefote took a bolder line. He urged, in a few pithy sentences, the importance of organizing a permanent international tribunal, the services of which might be called into requisition at will, and produced to the committee a short sketch of the mode in which such a tribunal might be set up. His proposition met with general acceptance, and the committee then proceeded to settle the necessary details for carrying it out, adopting in the main the code of procedure which had been suggested by Russia.

The result was embodied in twenty-seven articles, of which only the most important can be noted here. (Art. 23) Each of the signatory powers is to designate within three months from the ratification of the Convention four persons at the most, of recognized competence in international law, enjoying the highest moral consideration, and willing to accept the duties of arbitrators. Two or more powers may agree to nominate one or more members in common, or the same person may be nominated by different powers. Members of the court are to be appointed for six years, and may be re-nominated. (Art. 25) The signatory powers desiring to apply to the tribunal for the settlement of a difference between them are to notify the same to the arbitrators. The arbitrators who are to determine this difference are, unless otherwise specially agreed, to be chosen from the general list of members in the following manner:—each party is to name two arbitrators, and these are to choose a chief arbitrator or umpire (*sur-arbitre*). If the votes are equally divided the selection of the chief arbitrator is to be entrusted to a third power to be named by the parties. (Art. 25) The tribunal is to sit at the Hague when practicable, unless the parties otherwise agree. (Art. 27) "The signatory powers consider it a duty in the event of an acute conflict threatening to break out between two or more of them to remind these latter that the permanent court is open to them. This action is only to be considered as an exercise of good offices."

The procedure of the court is proposed to be regulated by twenty-seven articles, in which the following points are the most important. The agent of each party is first to communicate to the court and to the opposite party all deeds and documents on which it proposes to rely, one copy at least being in the language which the court authorizes to be used before it. After the documentary evidence has been lodged, the oral argument is to begin. This is to be taken down in writing, but it is only to be made public with the consent of the parties. The members of the tribunal may question the agents and counsel on any point which they desire to have cleared up. The tribunal is to be the sole judge of the extent of its own jurisdiction and of the rules of international law, if any, which are applicable to the case. The deliberations of the court are to take place with closed doors. The decision is to be that of the majority, and is to set forth the reasons on which it is based. It is to be in writing and signed by all the members, the minority members when appending their signature being at liberty to signify their dissent. There is to be no appeal; but if a new fact is discovered, which was unknown at the time both to the tribunal and to the party alleging it, and the fact be such that had it been then known it might have exercised a decided influence on the decision, that decision may be revised. Before, however, revision can be had, the tribunal must recognize the existence of the new fact or facts and admit them to have the characteristics just mentioned.

The Hague arbitration Convention was signed on 29th July 1899, on behalf of France, Russia, the United States, and thirteen other powers. It was also signed a few days later on behalf of Great Britain. On 4th September 1900, all the powers represented, with the exception of China, duly deposited formal ratifications of the Convention at the foreign office of the Dutch Government. Several of the powers nominated members of the Permanent Arbitration Court, pursuant to Art. 23 mentioned above, those nominated on behalf of Great Britain being Lord Pauncefote, Sir Edward Malet, Sir Edward Fry, and Professor Westlake.

Limits and Prospects.

Although, in some of the treaties and most of the projects enumerated above, the range of matters proper to be dealt with by international arbitration is assumed to be unlimited, there is a general consensus of opinion amongst specialists that some limitation there must be. Bluntschli, Rouard de Card, Goldschmidt, Kamarowski, Ferdinand Dreyfus, Michel Revon, all exclude questions of national independence, and some of them also exclude questions of "national honour" and of "territorial integrity." The language in which these reservations are couched is not, however, particularly happy, since it is open to more interpretations than one. What, for instance, is meant by the phrase "national independence" in this connexion? If it be taken in its strict acceptation of autonomous state sovereignty, the exception is somewhat of a truism. No self-respecting power would, of course, consent to submit to arbitration a question of life or death. This would be as if a man were to commit suicide in order to avoid fighting a duel. On the other hand, if the exception be taken to exclude all questions which, when decided adversely to a state, impose a restraint on its freedom of action, then the exception is too wide, since it would exclude such a question as the true interpretation of an ambiguous treaty, a subject with which experience shows international arbitration is well fitted to deal. Again, we may ask, what is meant by the phrase "national honour"? It was thought at one time that the honour of a nation could only be vindicated by war, though all that had happened was the slighting of its flag or its accredited representative during some sudden ebullition of local feeling. France once nearly broke off peaceful relations with Spain because her ambassador at London was assigned a place below the Spanish ambassador, and on another occasion she despatched troops into Italy because her ambassador at Rome had been insulted by the friends and partisans of the Pope. The truth is that the extent to which national honour is involved depends on factors which have nothing to do with the immediate subject of complaint. So long as general good feeling subsists between two nations, neither will easily take offence at any discourteous act of the other. But when a deep-seated antagonism is concealed beneath an unruffled surface, the most trivial incident will bring it to the light of day. "Outraged national honour" is a highly elastic phrase. It may serve as a pretext for a serious quarrel whether the alleged "outrage" be great or small. A similar criticism may be passed on the phrase "territorial integrity." Every boundary dispute is a dispute about territory, and nothing is easier than for a state to declare that the tract of land it covets forms, or—like the *angulus ille* of Horace—ought to form, an integral part of its dominions. Yet, as we have seen, this class of dispute is just that which has been most frequently arbitrated on, and in nearly every case successfully.

Weighing, then, each of these exceptions in the balance, and finding them all wanting in precision, we prefer to discard them altogether and to cast about for a fresh classification. M. Despagnet has suggested one in his work on *Public International Law* (Paris, 1894) which is both convenient and complete. All state differences, this writer points out, may be classed, as regards their subject matter, under one of two heads—(1) those which have a legal character, (2) those which have a political character. Under "legal differences" may be ranged as many as are capable of being decided, when once the facts are ascertained, by settled, recognized rules, or by rules not settled nor recognized but (as in the *Alabama* case) taken to be such for the purpose in hand. Boundary cases and cases of indemnity for losses sustained by non-combatants in time of war, of which we have already mentioned several instances, belong to this class. To it also belong those cases in which arbitrators have to adapt the provisions of an old treaty to new and altered circumstances, somewhat in the way in which English courts of justice apply the doctrine of *cy-pres*. Of these last the Newfoundland fishery case is an illustration. "Political differences," on the other hand, are such as affect states in their external relations or in relation to their subjects or dependants who may be in revolt against them. Some of these differences may be slight, whilst others may be vital, or (which amounts to the same thing) may seem to the parties to be so. All differences falling under the first of these two general heads appear to be suitable for international arbitration. Differences falling under the second general head are for the most part unsuitable, and may only be adjusted (if at all) through the mediation of a friendly power.

The interesting problem of the future is, Are we to regard this condition of things as permanent or as transitory? The answer depends on several considerations which can only be glanced at here. It may be that, just as the usages of civilized nations have slowly crystallized into international law, so there may come a time when the political principles that govern states in relation to each other will be so clearly defined and so generally accepted as to acquire something of a legal or quasi-legal character. If they do, they will pass the line which at present separates arbitrable from non-arbitrable matter. This is the juridical aspect of the problem. But there is also an economic side to it by reason of the conditions of modern warfare. As M. de Bloch has explained at some length in his monumental treatise on the subject, war has become much more terrible now than formerly, in consequence of the increase of armaments and the greater perfection of weapons of destruction. Already the nations are groaning under the burdens of militarism, and are for ever diverting energies that might be employed in the furtherance of useful productive work to purposes of an opposite character. The interruption of maritime intercourse, the stagnation of industry and trade, the rise in the price of the necessaries of life, the impossibility of adequately providing for the families of those—call them reservists, *landwehr*, or what you will—who are torn away from their daily toil to serve in the tented field, —these are considerations that may well make us pause before we abandon a peaceful solution and appeal to brute force. Lastly, there is the moral aspect of the problem. In order that international arbitration may do its perfect work, it is not enough to set up a standing tribunal, whether at the Hague or elsewhere, and to equip it with elaborate rules of procedure. Tribunals and rules are, after all, only machinery. If this machinery is to act smoothly we must improve our motive power, the source of which is human passion and sentiment. Although religious animosities between Christian nations have died out, although dynasties may now rise and fall without rousing half Europe to arms, the springs of warlike enterprise are still to be found in commercial jealousies, in imperialistic ambitions, and in the doctrine of the survival of the fittest which lends scientific support to both. These must one and all be cleared off the world's stage before we can enter on that era of universal peace towards the attainment of which the Tsar declared, in his famous circular of 1898, the efforts of all governments should be directed.

AUTHORITIES.—Amongst special treatises are—KAMAROWSKY, *Le tribunal international* (traduit par Serge de Westman), Paris, 1887; ROUARD DE CARD, *Les destinées de l'arbitrage international, depuis la sentence rendue par le tribunal de Genève*, Paris, 1892; MICHEL REVON, *L'arbitrage international*, Paris, 1892; ALESSANDRO CORSI (Marchese), *Arbitrati Internazionali*, Pisa, 1894; FERDINAND DREYFUS, *L'arbitrage international*, Paris, 1894 (where the earlier authorities are collected); A. MERIGNHAC, *Traité de l'arbitrage international*, Paris, 1895; LE CHEVALIER DESCAMPS, *Essai sur l'organisation de l'arbitrage international*, Bruxelles, 1896; FERAUD-GIRAUD, "Des traités d'arbitrage international général et permanent," *Revue de droit international*, Bruxelles, 1897. Of similar works in English there is a singular dearth. The most important is by an American, J. B. MOORE, *History of the International Arbitrations to which the United States has been a Party*, Washington, 1898. The Appendices to this work (which is in six volumes) contain, with much other matter of great value, full historical notes of arbitrations between other powers. Arbitration and Mediation will be found briefly noticed in PHILLIMORE'S *International Law;* in Sir HENRY MAINE'S *Lectures delivered in Cambridge* in 1887; in W. E. HALL'S *International Law* (Clarendon Press, Oxford); and more at length in an interesting paper contributed by Mr JOHN WESTLAKE to the *International Journal of Ethics*, Oct. 1896, which its author has reprinted privately. A London journal, *The Herald of Peace and International Arbitration*, issued some years ago a list of instances in which arbitration or mediation had been successfully resorted to during the 19th century. The late Mr Dudley Field, of New York, subsequently enlarged this list which has been revised down to 1899 by Dr W. Evans Darby, and is published, along with the texts of several projects for unlimited arbitration, at the offices of the Peace Society, 47 New Broad Street, London. *A History of the Hague Conference*, 1899, has been published by the International Arbitration Association, 40 Outer Temple, London. (M. H. C.)

Arboretum.—That part of a botanical garden which is reserved for the growth and display of trees is technically called an Arboretum. The term, in this restricted sense, was seemingly first so employed in 1838 by J. C. Loudon, in his book upon arboreta and fruit trees. Professor Bayley Balfour, F.R.S., the Regius Keeper of the Royal Botanic Garden in Edinburgh, has described an arboretum as a living collection of species and varieties of trees and shrubs arranged after some definite method—it may be properties, or uses, or some other principle,—but usually after that of natural likeness. The plants are intended to be specimens showing the habit of the tree or shrub, and the collection is essentially an educational one. According to another point of view, which is favoured by Mr. Charles Jordan, the Superintendent of Regent's Park, London, an arboretum should be constructed with regard to picturesque beauty rather than systematically, although it is admitted that for scientific purposes a systematic arrangement is a *sine quâ non*. In this more general respect, an arboretum affords shelter, improves local climate, renovates bad soils, conceals objects unpleasing to the eye, heightens the effect of what is agreeable and graceful, and adds value, artistic and other, to the landscape. What Loudon called the "gardenesque" school of landscape naturally makes particular use of trees. By common consent the arboretum in the Royal Botanical Gardens at Kew is the finest in the world. Its beginnings may be traced back to 1762, when, at the suggestion of Lord Bute, the Duke of Argyll's trees and shrubs were removed from Whitton Place, near Hounslow, to adorn the Princess of Wales's garden at Kew. The duke's collection was famous for its cedars, pines, and firs. Most of the trees of that date have perished, but the survivors embrace some of the finest of their kind in the gardens. The botanical gardens at Kew were thrown open to the public in 1841 under the directorate of Sir William Hooker. Including the arboretum, their total area did not then exceed 11 acres. Four years later the pleasure grounds and gardens at Kew occupied by the king of Hanover were given to the nation and placed under the care of Sir William for the express purpose of being converted into an arboretum. Hooker rose to the occasion, and, zealously reinforced by his son and successor, Sir Joseph—*patre claro filius clarior*,—established a collection which is alike the envy and admiration of the botanists of every country. The Kew nursery dates from 1850 and the new pinetum from 1870. Of the total acreage (250) of the Gardens, no fewer than 180 acres are monopolized by the arboretum. Of the more specialized arboreta in the United Kingdom the next to Kew are those in the Royal Botanic Garden in Edinburgh and the Glasnevin Garden in Dublin. The gardens of the Royal Botanical Society in London are beautifully wooded, but owing to the limited space at its disposal (18 acres), the Society has not been able to make a speciality of trees. This is also true of the oldest botanical garden in Great Britain, at Oxford, which was founded in 1632. The quaint "Physic" garden at Chelsea, which Sir Hans Sloane gave to the Apothecaries' Society, is devoted to medicinal plants and herbs. In the Botanical Gardens at Glasgow, where Sir W. J. Hooker laboured before his transference to Kew, there are many choice trees, and in Bournemouth the gardens of the Evergreen Valley constitute to all intents and purposes an arboretum, even to the labelling of the specimens. In the United States the Arnold Arboretum at Boston ranks next to Kew for size and completeness. It takes its name from its donor, the friend of Emerson. It was originally a well-timbered park, which, by later additions, now covers 222 acres. Practically, it forms part of the park system so characteristic of the city, being situated only four miles from the centre of population. There is a fine arboretum in the botanical gardens at Ottawa, in Canada (65 acres). On the continent of Europe the classic example is still the Jardin des Plantes in Paris, where, however, system lends more of formality than of beauty to the general effect. Of course superb collections of trees were made before arboreta, as such, were devised. Noblemen and other wealthy amateurs collected trees, as other rich men collected paintings or books. They spared neither pains nor money in acquiring specimens, even from distant lands, to which they sent out expert collectors at their own charges. This, too, the Royal Horticultural Society (founded, 1804; charter, 1809) was once wont to do, with fruitful results, as in the case of Mr David Douglas's remarkable expedition to North America in 1823-24. It will be remembered that when the Laird of Dumbiedikes lay dying (*The Heart of Midlothian*, chap. viii.) he gave his son one bit of advice which Bacon himself could not have bettered. "Jock," said the old reprobate, "when ye hae naething else to do, ye may be aye sticking in a tree; it will be growing, Jock, when ye're sleeping." Sir Walter assures us that a Scots earl took this maxim so seriously to heart that he planted a large tract of country with trees, a practice which in these days is promoted by the English and Royal Scottish Arboricultural Societies.

For the cultivation of trees, both in its technical and economic sense, the reader is referred to the exhaustive article on ARBORICULTURE in the ninth edition of this work and the article on FORESTS in this Supplement. (J. A. M.)

Arbroath, a royal and parliamentary burgh (Montrose group), seaport and manufacturing town of Forfarshire, Scotland, 77 miles N.N.E. of Edinburgh by rail. Spinning and weaving factories number over 30, and there are engineering works, boot factories, and chemical works. In 1877 the old harbour was converted into a wet dock, and the new harbour and entrance deepened. There is a shipbuilding yard, and at the end of 1898, 11 vessels of 1959 tons were registered as belonging to the port. Entrances and clearances were:—1898, entered 243 vessels of 30,588 tons, cleared 246 vessels of 29,435 tons. Recent erections include two churches, parish church (rebuilt), free library, guild hall (rebuilt), and academy. Population (1881), 21,995; (1901), 22,372.

Arcachon, a modern sea-side town of France, department of Gironde, arrondissement of Bordeaux, 37 miles W.S.W. of that city. It comprises two distinct parts, the summer town, extending for three miles along the shore on a firm sandy beach, and the winter town, more inland, with numerous villas scattered amongst pine woods, resorted to by consumptive patients. The neighbouring forest has an area of about 1300 square miles. The principal industries are oyster-culture and fishing. The former is conducted on a very large scale; there are 5900 oyster parks, covering an area of over 8000 acres, yielding, in 1898, 319,772,100 oysters, of the total value of £112,000. The port has trade with Spain and England. Population, 8000.

Arch, Joseph (1826-——), founder of the National Agricultural Labourers' Union, was born at Barford, a village in Warwickshire, 10th November 1826. His parents belonged to the labouring class. He inherited a strong sentiment of independence from his mother; and his objections to the social homage expected by those whom the catechism boldly styled his "betters" made him an "agitator." Having educated himself by unremitting exertions, and acquired fluency of speech as a Methodist local preacher, he founded in 1872 the National Agricultural Labourers' Union, of which he was president. A rise then came in the wages of agricultural labourers, but this had the unforeseen effect of destroying the union; for the labourers, deeming their object gained, ceased to "agitate." Mr Arch nevertheless retained sufficient popularity to be returned to Parliament for North-west Norfolk in 1885; and although defeated next year owing to his advocacy of Irish Home Rule, he regained his seat in 1892, and held it in 1895, retiring in 1900. He was deservedly respected in the House of Commons; seldom has an agitator been so little of a demagogue. A biography written by himself or under his direction, and edited by Lady Warwick (1898), tells the story of his career.

ARCHÆOLOGY (CLASSICAL).

IT is proposed in the present article to give some account of the progress and the results of archæological investigation in regard to the monuments of ancient Greece and Rome in the years since the publication of the ninth edition of this work. The articles on classical archæology and architecture were published in 1875, that on gems in 1879, that on pottery in 1885, that on terracottas in 1888. Generally speaking, therefore, we have to report the progress of twenty-five years. It is not intended here to re-discuss questions considered in the articles above mentioned, except so far as this may be made necessary by the discovery of new materials. For an account of the excavations carried on at various classical sites in recent years, the reader is referred to special articles in the present publication. Especially we must mention the articles on Athens, Eleusis, Mycenæ, Cyprus, Epidaurus, Megalopolis, Dodona, Rome, Delphi. In the present article the results of these excavations will be considered, not on the topographic or architectural side (see ARCHITECTURE, II.), but only in so far as they have extended our knowledge of ancient art, especially of sculpture. We begin with a general account of the progress made in institutions, in publications, and in excavations connected with classical archæology; afterwards we shall give, under periods, a more detailed account of recently discovered monuments and works of art, with the information to be derived from them.

Archæological Institutes.—Perhaps in no respect has the activity of the last quarter of the 19th century been more marked than in the founding and organization of institutions for the forwarding of archæological research. The old international "Instituto di Corrispondenza Archeologica" has been transmuted into the Roman branch of the German Archæological Institute. That great institution, which is the main centre of archæological activity, has its headquarters at Berlin, with branches at Rome and Athens. The French have also schools at Rome and Athens, as have now the English and Americans. Austria has recently established a powerful institute, with various branches. The Society for the Promotion of Hellenic Studies in England, the Archæological Institute in America, the Accademia dei Lincei in Italy, and the Greek Archæological Society, are all active in publishing journals, in finding the funds for excavations, and the scholars to take charge of them, and in extending archæological knowledge. France, Germany, and Austria provide from the public purse bursaries to trained archæological students, enabling them to stay for a term of years at the schools of Athens and Rome for purposes of study and research. In Germany also a certain number of teachers in the schools are every year provided with the means of making archæological tours in Greece and Italy, under the guidance of the best specialists; while in the great museums of Germany holiday courses are annually arranged for the benefit of students who wish to keep abreast of the progress of archæological discovery. In England and America efforts are made to work by private subscription in the same direction in which so much is done by the governments of the Continent with public funds. Travelling studentships at the universities, and bursaries awarded by the Committee of the British School at Athens, avail to prevent England from being entirely left behind in the movement; and the funds of the American Institute have in recent years enabled American students to do much excellent work in exploration.

Naturally also the great museums of Europe are not only centres of research, and keenly alive to the necessity of procuring fresh objects, but also are awake to the duty of publishing in a systematic way the works of ancient art which they contain. Besides the public museums, we may mention, in this connexion, the Ny-Carlsberg collection at Copenhagen, the Tyszkiewicz collection, and the Barracco collection, the contents of which are published in excellent form.

Archæological publications.

Journals.—The most important periodicals in connexion with classical archæology are now the following:—Published in English: the *Journal of Hellenic Studies*, the *Annual of the British School at Athens*, *Archæologia*, the *American Journal of Archæology*. Published in French: *Bulletin de Correspondance Hellènique*, *Revue Archéologique*, *Monuments et Mémoires, Piot.* Published in German: *Jahrbuch des Arch. Instituts*, *Mittheilungen des Arch. Instituts, Römische Abtheilung* and *Athenische Abtheilung*, *Jahreshefte des oesterreich. Arch. Instituts.* Published in Italian: *Monumenti Antichi* and *Atti dell' Accad. dei Lincei*, *Bulletino della Commiss. Archeol. Comunale di Roma.* Published in Greek: *Ephemeris Archaiologikê*, *Deltion Archaiologikon.* To the subject of coins in particular, numismatic journals are dedicated in almost all countries of Europe; among them the English *Numismatic Chronicle* occupies a satisfactory position.

Books.—To give any complete account, or even a bare list, of important works on classical archæology published during the last twenty-five years would exceed the space at our disposal. We can select only a few works of special value, mentioning more particularly those which are published in English.

(1) **General Handbooks.**—Manuals of Classical Archæology have been published by Mr. A. S. Murray and Mr. Talfourd Ely. There is also a new brief *History of Greek Art* by Prof. F. B. Tarbell. Miss J. E. Harrison has published some *Introductory Studies in Greek Art.* A more complete *Griechische Kunstgeschichte* by Prof. Brunn, begun in 1893, does not come down below the archaic period. Sittl's *Klassische Kunst-Archäologie* is useful as a compendium. A new edition by Wernicke (recently deceased) of C. O. Müller's *Denkmäler der alten Kunst* is in progress. Of the greatest value to the ordinary scholar is Baumeister's *Denkmäler*, a dictionary of archæological evidence suited for easy reference. To those who wish to procure a mass of archæological material at moderate cost, it is safe to commend M. S. Reinach's *Répertoire de la statuaire grecque et romaine* and *Répertoire des vases peints grecs et étrusques*, published at five francs a volume, with his other cheap reprints of expensive works.

(2) **Architecture.**—There is no recent systematic work in English on classical architecture, but Mr Penrose's *Principles of Athenian Architecture* (new edition) is a work of importance. Besides the handbooks already mentioned, which give chapters to architecture, we may refer to the seventh volume of Perrot and Chipiez's *Histoire de l'art dans l'antiquité* (*La Grèce archaique*), Botticher's *Tektonik der Hellenen*, and Uhde's *Architekturformen des class. Alterthums*, as well-illustrated and standard works.

(3) **Sculpture.**—A. S. Murray's *History of Greek Sculpture* and E. A. Gardner's *Handbook of Greek Sculpture* are important works; as is also H. Stuart Jones's *Ancient Writers on Greek Sculpture.* There are also valuable histories of Greek sculpture in French by Collignon, and in German by Overbeck (4th edit. 1893). Among recent books on sculpture in English may be mentioned Waldstein's *Essays on the Art of Pheidias*, Furtwangler's *Masterpieces of Greek Sculpture*, Michaelis's *Ancient Marbles in Great Britain*, and P. Gardner's *Sculptured Tombs of Hellas.* The German literature of the subject is very extensive.

(4) **Vases.**—A good book on Greek vases is at present a crying need. The most useful general book on the subject is Rayet and Collignon's *Histoire de la céramique grecque.* For archaic vases, Dumont and Chaplain's *Céramiques de la Grèce propre* is valuable, though somewhat out of date (1888). Prof. Furtwangler has just issued the first part of a great work on Greek vases, the plates of which are executed with great care, so as faithfully to represent the style of the vases. We have in English, Harrison and Maccoll's *Greek Vase Paintings*, and A. S. Murray's *Designs from*

Greek Vases in the British Museum, and *White Athenian Vases*; also the illustrated catalogues of vases in the British Museum, the Ashmolean and Fitzwilliam Museums, and the Louvre. Three small works in German by W. Klein, *Euphronios*, *Vasen mit Meistersignaturen*, and *Vasen mit Lieblingsinschriften*, are indispensable to the student. The best general collection of vase-paintings is still Gerhard's *Auserlesene Vasenbilder*, 1840.

(5) **Terra Cottas.**—Two small works can be recommended: E. Pottier's *Statuettes de terre cuite*, and Miss C. A. Hutton's *Greek Terra-Cotta Statuettes*, which is published with A. S. Murray's *Greek Bronzes*.

(6) **Gems.**—A recent work is J. H. Middleton's *Engraved Gems of Classical Times*. But quite recently A. Furtwangler has published a large work on Greek gems, *Antike Gemmen*, which is the product of vast learning, and must needs form the basis of future study.

(7) **Coins.**—No branch of archæology has been more completely transformed in the last quarter of a century than numismatics. Previously, coins had been treated, much as gems are, as individual works of art, beautiful in themselves, and giving valuable information as to ancient mythology and geography. But in recent years the close and intimate relations which prevail between the coins of ancient cities and the history of those cities have been more closely regarded, from which point of view the exact dates and weights of the coins become most important. The strictly historic treatment of Roman coins was begun by Mommsen in his *Geschichte des römischen Munzwesens*. A similar treatment of Greek coins is attempted by Mr B. V. Head in his *Historia Numorum*, a work in which an endeavour is made to arrange the coins of all Greek cities under periods, in close connexion with the history of those cities. The *British Museum Catalogue of Greek Coins*, which is dominated by the same purpose, is now approaching completion. The *Historia Numorum* is the most useful work to a collector of Greek coins. To a collector of Roman coins M. Babelon's editions of Cohen's *Monnaies de la république romaine*, and *Monnaies de l'empire romain* are necessary. Mr G. F. Hill's *Handbook of Greek and Roman Coins* is an excellent summary. Prof. Ridgeway has published a work on the *Origin of Currency and Weight-Standards*. P. Gardner's *Types of Greek Coins* deals mainly with the art of coins.

(8) **Corpuses.**—The Academies of Berlin and Vienna have done much in recent years in the way of publishing vast collections and compendia of ancient monuments, each of which is a *Corpus*, that is, contains all known monuments of the class dealt with. It is impossible to overrate the value of these monumental publications, each of which, being complete up to the date of publication, relieves the student from the necessity of hunting through books of an earlier date. The *Corpus of Greek Inscriptions* by Boeckh, and the more recent *Corpus of Roman Inscriptions* and *Corpus of Attic Inscriptions* are well known. To these are now added, a *Corpus of Attic Sepulchral Monuments* (nearly complete), a *Corpus of Sarcophagi*, a *Corpus of Terra-Cottas*, a *Corpus of Greek Coins*, all in course of gradual publication. Other works of the same class are in preparation. The labour of producing these works is enormous, and for the most part it is unpaid, German archæologists freely spending their lives in the effort to advance scientific knowledge.

(9) **Other Works.**—Besides the works mentioned, we may set down a few books of a more general character: C. Diehl's *Excursions in Greece*, P. Gardner's *New Chapters in Greek History*, D. G. Hogarth's *Authority and Archæology, Sacred and Profane*, Lady Evans's *Greek Dress*, and the dictionaries of classical antiquities.

The valuable translation of and commentary on Pausanias' *Description of Greece*, by J. G. Frazer, has enabled the English reader for the first time to grasp the results of the great intellectual activity of the archæologists at Athens. The edition of Pliny's *Chapters on the History of Art*, by Misses Jex-Blake and Sellers, is also important. In the matter of bringing ancient monuments into relation with Greek mythology, the books of C. O. Muller have been succeeded by far more elaborate and completer works. Most comprehensive of all these is Overbeck's *Kunstmythologie*. The collection here made of monuments bearing on the cults of Zeus, Hera, Demeter, Poseidon, and Apollo is enormous; unfortunately, the completion of the work has been prevented by Prof. Overbeck's death. For monuments relating to other deities, we have to go to the *Lexicons* of Baumeister and Roscher. Mr L. R. Farnell has published in English a work called *Cults of the Greek States*, which deals in detail with the art representations of some of the Greek deities.

Research and Excavation.—Three sites of the first importance in Greece proper have been carefully excavated in the last quarter of a century, besides those like Troy, Tiryns, and Mycenæ, which have yielded mainly prehistoric monuments. These are Olympia, the Athenian Acropolis, and Delphi. The excavation at Olympia was carried out at great cost by the German Government; and the results are published in a series of vast and costly volumes, which are epoch-making in the development of archæology. It must not be forgotten that in the thorough investigation of a great site like Olympia, which was for ages one of the chief centres of Greek life and art, the whole result is far greater than the sum of the separate discoveries. It is not merely that we have gained a knowledge of the plans of buildings and of their architectural details, a series of valuable works of sculpture and bronzes, and the text of a number of important documents recording treaties and decrees and public honours. We further discover the relations of these monuments among themselves. Their very situations and the level of their bases show us their respective dates and their comparative importance. We find ourselves in a museum, but in a museum not arranged on any arbitrary principle, but, so to speak, by the hands of history herself, affording us almost infinite opportunities for comparing, inferring, and connecting the remains which have come down to us with ancient belief and custom.

Of Delphi it is too early to speak, as the excavators to whom the task of its exploration has been confided by the French Government have as yet published but few of their results. But enough is known to assure us that the harvest on this site also is very rich. The topography of the site and the position of the main buildings and the principal dedications can be determined with accuracy. In sculpture of the end of the 6th and the early part of the 5th century, the site is certainly very rich, and the inscriptions are already known to be very numerous and of great historic value. (See DELPHI.)

The acropolis of Athens (*q.v.*) has been carefully and completely excavated by the Greek Archæological Society. The great importance of the finds is mainly due to an event which, at the time, must have seemed fatal to all record of the city's beauty—the havoc wrought by the Persians, when they occupied the rock-fortress in 480 B.C. When the Athenians in the next year, after the victory of Platæa, returned to their citadel, they found it a mass of ruins, and nothing remained but to bury out of sight the shattered fragments of their shrines and the works of art which had been dedicated to their goddess. But their loss has been our gain, for the wreck of the ruined Athens of the early 5th century has rested quietly in the ground from that day to this, and has only now been dragged forth and ranged in the Athenian museums. To the archæologist, nothing seems more desirable than to secure a fixed date for a series of monuments. And on this site the year 480 is defined by the circumstances of the case as the time below which all the monuments to be found in certain strata cannot be brought. We are thus able to reconstruct in imagination, at all events in outline, the surface of the Acropolis as it existed in the days of Pisistratus and of Themistocles.

The extensive precinct of the god Æsculapius in the neighbourhood of Epidaurus has also been cleared by the Greek archæologists under M. Kavvadias. Here the main interest, besides that which belongs to recovered fragments of buildings and series of sculptures, arises from the fact that Epidaurus was a sort of Baden of antiquity, a resort of those who were out of health and sought recovery either at the hands of the physician-god, or from the natural salubrity of the place and its healthful regimen. We find on the spot not only shrines of the deities, but covered seats shielded from all the winds, an abundant supply of water for baths, porticoes as a refuge from summer heat, and a theatre and a stadium for the refreshment of the mind and the exercise of the body. (See Epidaurus.)

Many other sites in Greece proper have yielded valuable results. At Megalopolis, a party of English students have recovered the plans of various buildings, in particular of the theatre and the hall of assembly where the representatives of the cities of Arcadia met in conclave. The ground plan of Corinth is being rapidly recovered by American archæologists, who have also succeeded in revealing the phases which the Argive Heræum passed through in the course of long ages. The temples of Apollo Ptoos in Bœotia, of Athena Alea at Tegea, of the great goddesses at Lycosura have also been in part brought to light, with happy results for the history of Greek sculpture. Of these results we shall have to speak further in the course of this article.

Among the islands of the Ægean, there has been of late years much research and excavation. The results belong in great part to the prehistoric age of Greece, and are spoken of in the article on Mycenæan Civilization. But Delos in particular has furnished us not only with the foundations of temples and the plans of private houses, but also with some very important examples of sculpture, which may be said to give us the clue to the history of the rise of the art.

Mr Petrie's important excavations in Egypt, and the more recent and equally striking discoveries of Mr A. J. Evans in Crete, have been valuable as fixing the dates of early classes of Ægean and Mycenæan pottery, and revealing to us the nature of the early Ægean civilization. And the site of Naucratis in particular, excavated by Mr Petrie and Mr Ernest Gardner in 1884-86, has given us dates for various kinds of early Ionian pottery, as well as furnished us with valuable data for recovering the history of the Greek alphabet.

Partial excavations have been made on the sites of some of the great Ionian cities of Asia Minor. At Ephesus, the researches of Wood, which have enriched the British Museum with many architectural and sculptural fragments from the great temple of Artemis, have been resumed by the Austrian Government. The temple of Apollo at Miletus has been explored by MM. Rayet and Thomas; further excavations are taking place on this site. The Americans have made extensive excavations at Assos. The site of Pergamon, which has been occupied by the German Archæological Institute, has yielded results which have added an important chapter to Greek art, and shown us the sculptors of Greece working under new conditions and in a new style. Clazomenæ and other cities have furnished us from their burying-grounds sarcophagi and painted vases which throw light on the origin and early history of Ionian art. It is unnecessary to proceed further with this enumeration; what has been written will be sufficient to give the reader some idea of the energy with which excavation has been carried on in Greece of late years, and of the richness and variety of the results which it has attained.

Turning to Italy, we naturally think first of Rome. In that centre of the world, the main interest of all excavation must be topographic and historic, and for results of this character the reader must turn to the article Rome. But in the course of investigation a great number of important works of ancient sculpture and painting have been brought to light, most of which now adorn the museums of the Capitol and the new museum of the Terme. We may instance the wonderful bronze figures of a Hellenistic king and of a pugilist, and the wall-paintings of the house at Prima Porta. Of other excavations in Italy, an excellent summary will be found in Prof. von Duhn's article in vol. xvi. of the *Journal of Hellenic Studies*. At Locri two Ionic temples have been discovered. The building of an arsenal at Tarentum has been the occasion of the discovery of very rich deposits of terra-cotta votive offerings. At Pompeii a house of great beauty and interest, which bears the name of the Vettii, has been found, and has furnished a number of fresh paintings. Excavations at Falerii deserve a particular mention, because their results are separately arranged in a special museum at Rome, that of the Villa Papa Giulio, giving us materials for tracing the artistic history of the city from period to period. At this museum is also a very attractive restoration of a Greek temple, with its decoration in terra-cotta and its brilliant colouring.

The researches of Signor Orsi in Sicily on the sites of Megara and Syracuse have resulted in the establishment of an archæological history of Sicily, which may be traced in the museums of Syracuse and Palermo from the earliest days down to the period of Greek invasion, and onwards to the Roman age. The site of Selinus, which has long been a valuable mine of sculpture of the early period, has again in recent years furnished us with metopes from its temples of great interest; and the plan of the city has now been in great measure laid bare, as well as of the fortifications erected by Hermocrates, when at the end of the 5th century he turned the ruins of the town into a fortress whence to wage war against the Carthaginians. No country is more full of the memorials of history than Sicily; but we cannot pursue this subject; we must refer the reader to the ample and most interesting history of Sicily by Mr Freeman, a writer who fully understood how much light existing remains may cast on the past history of a city.

Theatres.

A class of ancient buildings which has received special attention in recent years is the great open-air theatres with which every Greek city was provided. Fresh theatres have been excavated at Piræus, Eretria, Delos, Megalopolis, Epidaurus, and other places; and the model of all such erections, the theatre of Dionysus at Athens, has been most carefully investigated. In this work the leading part has been taken by Dr Dörpfeld of Athens. The result has been the setting forth by Dr Dörpfeld, with the utmost skill, of the view that there was no stage in use in Greek theatres, but that the actors and the chorus performed together in the space at the back of the orchestra, and in front of the stage buildings. (See Dorpfeld and Reisch, *Das griechische Theater*.) This novel view has met with severe criticism in Germany, and especially in England. The arguments against it are set forth by Haigh, in his *Attic Theatre*. It is likely that scholars will long be divided in their opinions as to the existence or non-existence of a stage among the Greeks. In the opinion of the present writer it can be proved from extant remains that a stage was in use in Greek theatres of the 3rd century B.C., and although we cannot demonstrate that the same was the case in the days of the great Attic tragedians, it is by far the most likely supposition. However this be, the researches and the book of Dr Dörpfeld have enabled us to approach all questions in regard to the staging of Greek plays with far greater knowledge.

Houses.

The materials for a reconstruction of the private houses of the Greeks have also been rapidly accumulating. At Delos, at Assos, at Priene, and on other sites, the plans of ancient houses have been brought to light. At present, few of these plans have been published; but it has become clear that we have hitherto been misled by Vitruvius into the belief that Greek houses were of uniform plan, like the temples; whereas they varied greatly according to the ground, the fortune of the builder, or the fashion of the district. For gaining a sense of the external conditions of ancient life, Pompeii is still by far the most useful site. The recent book on Pompeii by Mau, translated by Kelsey, is by a writer who has an unequalled knowledge of the site; and the more ambitious work of C. Weichardt (*Pompei vor der Zerstoerung*) brings before the reader's eyes, by means of skilled restorations, the actual state of Pompeii before its sudden destruction.

We propose next to treat briefly of the advances made by recent discovery in our knowledge of Greek and Roman monuments and art, dividing our account into the same periods which Mr Murray has adopted in his article, CLASSICAL ARCHÆOLOGY, in the ninth edition of this Encyclopædia.[1]

The periods accepted are the following:—I. 900-700 B.C. II. 700-480 B.C. III. 480-400 B.C. IV. 400-320 B.C. V. After 320 B.C.

Period I. 900-700 B.C.

In Mr. A. S. Murray's earlier article the art of the later prehistoric age of Greece, now usually called the Mycenæan age, is included with that of historic Greece, to which indeed it naturally serves as an introduction. But for our present purposes the art of Mycenæ is reserved for separate treatment (see MYCENÆAN CIVILIZATION). We have therefore to deal only with the art which succeeded that called Mycenæan, beginning about the year 900 B.C. The fact is now generally allowed that the Mycenæan civilization was for the most part destroyed by an invasion from the north. This invasion appears to be that called in Greek tradition the Dorian immigration. Archæological evidence abundantly proves that it was the conquest of a more by a less rich and civilized race. In the graves of the period 900-700 B.C. we find none of the wealthy spoil which has made celebrated the tombs of Mycenæ and Baphion (Vaphio). The character of the pottery and the bronze-work which is found in these later graves reminds us of the art of the necropolis of Hallstadt in Austria, and other sites belonging to what is called the bronze age of North Europe. Its predominant characteristic is the use of geometrical forms, the lozenge, the triangle, the meander, the circle with tangents, in place of the elaborate spirals and plant-forms which mark Mycenæan ware. For this reason the period from the 9th to the 7th century in Greece passes by the name of "the Geometric Age." It would seem that in the remains of the Geometric Age we may trace the influence of the Dorians, who, coming in as a hardy but uncultivated race, probably of purer Aryan blood than the previous inhabitants of Greece, not only brought to an end the wealth and the luxury which marked the Mycenæan age, but also replaced an art which was in character essentially Oriental by one which belonged rather to the North and the West. The great difficulty inherent in this view, a difficulty which has yet to be met, lies in the fact that some of the most abundant and characteristic remains of the geometric age which we possess come, not from Peloponnesus, but from Athens and Bœotia, which were never conquered by the Dorians.

Dorian invasion.

The geometric ware is for the most part adorned with painted patterns only. We engrave (Fig. 1) a characteristic example, a small two-handled vase from Rhodes in the Ashmolean Museum, the adornment of which consists in zigzags, circles with tangents, and lines of water-birds, perhaps swans. Other geometric vases will be found in *Ency. Brit.* vol. xix. p. 607, Fig. 16. Sometimes, however, especially in the case of large vases from the cemetery at Athens which adjoins the Dipylon gate, scenes from Greek life are depicted, from daily life, not from legend or divine myth. Especially scenes from the lying in state and the burial of the dead are prevalent. We engrave an excerpt from a Dipylen vase (Fig. 2), in which is seen a dead man on his couch surrounded by mourners, male and female. Both sexes are apparently represented naked, and are distinguished very simply; some of them hold branches to sprinkle the corpse or to keep away flies. It will be seen how primitive and conventional is the drawing of this age, presenting a wonderful contrast to the free drawing and realistic modelling of the Mycenæan age. In the same graves with the pottery are sometimes found plaques of gold or bronze, and towards the end of the geometric age these sometimes bear scenes from mythology, treated with the greatest simplicity. For example, in the museum of Berlin are the contents of a tomb found at Corinth, consisting mainly of gold work of geometric character. But in the same tomb were also found gold plates or plaques of *repoussé* work bearing subjects from Greek legend. Two of these (Fig. 3) we engrave. On one plate Theseus is slaying the Minotaur, while Ariadne stands by and encourages the hero. The tale could not have been told in a simpler or more straightforward way. On another plate we have an armed warrior with his charioteer in a chariot drawn by two horses. The

Geometric ware.

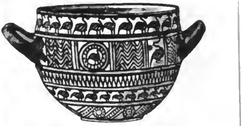


FIG. 1.—Geometric vase from Rhodes. Ashmolean Museum.

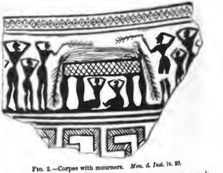


FIG. 2.—Corpse with mourners. *Mon. d. Inst.* ix. 39.

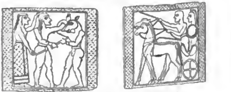


FIG. 3.—Gold plaques: Corinth. *Arch. Zeit.* 1884, 8.

---

[1] It is not to be supposed that the present writer agrees with all the views set forth by Mr Murray in that article; on many of the subjects of which he treats scholars will always differ among themselves.

treatment of the human body is here more advanced than on the vases of the Dipylon. On the site of Olympia, where Mycenæan remains are not found, but the earliest monuments seem to belong to the Dorian age, a quantity of dedications in bronze have been found, the decoration of which belongs to this style. We engrave (Fig. 4) the handle of a tripod from Olympia, which is adorned with geometric patterns and surmounted by the figure of a horse. In the 7th century, however, it was not unusual to adorn votive tripods and coffers with mythologic representations. Especially interesting is one plate of bronze, also from Olympia, used for some such purpose (Fig. 5), and showing in *repoussé* work, finished with the graving tool, a winged Artemis grasping two lions, and Herakles shooting a centaur, whose front legs are human, not equine. In the upper lines of the relief are pairs of eagles and griffins. Another similar plate represents again Herakles shooting. More than one breastplate has come from Olympia engraved by the tool with scenes such as one finds on early vases. Votive models of animals are also abundant. In fact, the history of Greek art from 800 to 500 B.C. can be nowhere better traced than in the plates of Furtwängler's great work on the bronzes of Olympia.

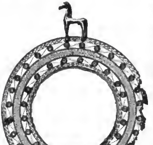


FIG. 4.—Handle of tripod: *Olympia*, iv. 33.

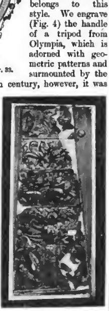


FIG. 5.—Bronze plate: Olympia.

Period II. 700-480 B.C.

It was in the 6th century that the genius of the Greeks, almost suddenly, as it seems to us, emancipated itself from the thraldom of tradition and passed beyond the limits with which the nations of the East and West had hitherto been content, in a free and bold effort towards the ideal. Thus the 6th century marks the stage in art in which it may be said to have become definitely Hellenic. The Greeks still borrowed many of their decorative forms, through Phœnician agency, from the old-world empires of Egypt and Babylon, but they used those forms freely to express their own meaning. And gradually, in the course of the century, we see both in the painting of vases and in sculpture a national spirit and a national style forming under the influence of Greek religion and mythology, Greek athletic training, Greek worship of beauty. We must here lay emphasis on the fact, which is sometimes overlooked in an age which is greatly given to the Darwinian search after origins, that it is one thing to trace back to its original sources the nascent art of Greece, and quite another thing to follow and to understand its gradual embodiment of Hellenic ideas and civilization. The immense success with which the veil has in late years been lifted from the prehistoric age of Greece, and the clearness with which we can discern the various strands woven into the web of Greek art, have tended to fix our attention rather on what Greece possessed in common with all other peoples at the same early stage of civilization than on what Greece added for herself to this common stock. In many respects the art of Greece is incomparable—one of the great inspirations which have redeemed the world from mediocrity and vulgarity. And it is the searching out and appreciation of this unique and ideal beauty in all its phases, in idea and composition and execution, which is the true task of Greek archæological science.

Ionian vases.

In very recent years it has been possible, for the first time, to trace the influence of Ionian painting, as represented by vases, on the rise of art. The discoveries at Naucratis and Daphnæ in Egypt, due to the keenness and pertinacity of Mr Petrie, opened a new light in this matter. It became evident that when those cities were first inhabited by Ionian Greeks, in the 7th century, they used pottery of several distinct but allied styles, the most notable feature of which was the use of the lotus in decoration, the presence of continuous friezes of animals and of monsters, and the filling up of the background with rosettes, lozenges, and other forms. We engrave a vase found in Rhodes (Fig. 6) to illustrate this Ionian decoration. The sphinx, the deer, and the swan are prominent on it, the last-named serving as a link between the geometric ware and the more brilliant and varied ware of the Ionian cities. The assignment of the many species of early Ionic ware to various Greek localities, Miletus, Samos, Phocæa, and other cities, is a work of great difficulty, which is now closely occupying the attention of archæologists. For the results of their studies the reader is referred to two recent German works, Boehlau's *Aus ionischen und italischen Nekropolen*, and Endt's *Beiträge zur ionischen Vasenmalerei*. The feature which is most interesting in this pottery from our present point of view is the way in which representations of Greek myth and legend gradually make their way, and relegate the mere decoration of the vases to borders and neck. One of the earliest examples of representation of a really Greek subject is the contest of Menelaus and Euphorbus on a plate found in Rhodes (*Ency. Brit.* xix. p. 611, Fig. 24). On the vases of Melos, of the 7th century, which are, however, not Ionian, but rather Dorian in character, we have a certain number of mythological scenes, battles of Homeric heroes, and the like. One of these we engrave (Fig. 7). It represents Apollo in a chariot drawn by winged horses, playing on the lyre, and accompanied by a pair of Muses, meeting his sister Artemis. It is notable that Apollo is bearded, and that Artemis holds her stag

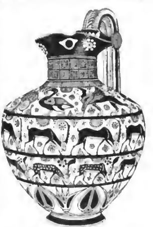


FIG. 6.—Jug from Rhodes. *Mus. Napoléon*, 57.

by the horns, much in the manner of the deities on Babylonian cylinders; in the other hand she carries an arrow; above is a line of water-birds.

Some sites in Asia Minor and the islands adjoining, such cities as Samos, Cameirus in Rhodes, and the Ionian colonies on the Black Sea, have furnished us with a mass of ware of the Ionian class, but it seldom bears interesting subjects; it is essentially decorative. For Ionian ware which has closer relation to Greek mythology and history we must turn elsewhere. The cemeteries of the great Etruscan cities, Cære in particular, have preserved for us a large number of vases, which are now generally recognized as Ionian in design and drawing, though they may in some cases be only Italian imitations of Ionian imported ware. Thus has been filled up what was a blank page in the history of early Greek art. The Ionian painting is unrestrained in character, characterized by a license not foreign to the nature of the race, and wants the self-control and moderation which belong to Doric art, and to Attic art after the first.

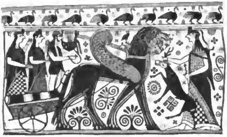


FIG. 7.—Vase painting: Melos. Conze, *Mel. Thongefässe*, 4.

Some of the most interesting examples of early Ionic painting are found on the sarcophagi of Clazomenæ. In that city in archaic times an exceptional custom prevailed of burying the dead in great coffins of terra-cotta adorned with painted scenes from chariot-racing, war, and the chase. The British Museum possesses some remarkable specimens, which are published by Mr Murray in his *Terra-Cotta Sarcophagi of the British Museum*. On one of them he sees depicted a battle between Cimmerian invaders and Greeks, the former accompanied to the field by their great war-dogs. In some of the representations of hunting on these sarcophagi the hunters ride in chariots, a way of hunting quite foreign to the Greeks, but familiar to us from Assyrian wall-sculptures. We know that the life of the Ionians before the Persian conquest was refined and not untinged with luxury, and they borrowed many of the stately ways of the satraps of the kings of Assyria and Persia.

In Fig. 8 we engrave a curious product of the Ionian workshops, a fish of solid gold, adorned with reliefs which represent a flying eagle, lions pulling down their prey, and a monstrous sea-god among his fishes. This relic is the more valuable on account of the spot where it was found — Vettersfelde in Brandenburg. It furnishes a proof that the influence and perhaps the commerce of the Greek colonies on the Black Sea spread far to the north through the countries of the Scythians and other barbarians. The fish dates from the 6th century B.C.

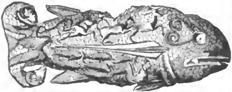


FIG. 8.—Fish of gold. Furtwängler, *Goldfund v. Vettersfelde*.

From Ionia the style of vase-painting which has been called by various names, but may best be termed the "orientalizing," spread to Greece proper. Its main home here was in Corinth; and small Corinthian unguent-vases bearing figures of swans, lions, monsters, and human beings, the intervals between which are filled by rosettes, are found wherever Corinthian trade penetrated, notably in the cemeteries of Sicily. For the larger Corinthian vases, which bore more elaborate scenes from mythology, we must again turn to the graves of the cities of Etruria. Here, besides the Ionian ware, of which mention has already been made, we find pottery of three Greek cities clearly defined, that of Corinth, that of Chalcis in Eubœa, and that of Athens. Corinthian and Chalcidian ware is most readily distinguished by means of the alphabets used in the inscriptions (see *Ency. Brit.* xix. p. 609), which have distinctive forms easily to be identified. Whether in the paintings coming from the various cities any distinct differences may be traced is a far more difficult question, into which we cannot now enter. The subjects are mostly from heroic legend, and are treated with great simplicity and directness. There is a manly vigour about them which distinguishes them at a glance from the laxer works of Ionian style. We figure (Fig. 9) a group from a Chalcidian vase which represents the conflict over the dead body of Achilles. The corpse of the hero lies in the midst, the arrow in his heel. The Trojan Glaucus tries to drag away the body by means of a rope tied round the ankle, but in doing so is transfixed by the spear of Ajax, who charges under the protection of the goddess Athena. Paris on the Trojan side shoots an arrow at Ajax. The other combatants of the group we omit for want of space. In Fig. 10 is a scene from a Corinthian vase. Ajax falls on his sword in the presence of his colleagues, Odysseus and Diomedes. The short stature of Odysseus is a well-known Homeric feature. These vases are black-figured; the heroes are painted in silhouette on the red ground of the vases. Their names are appended in archaic Greek letters.

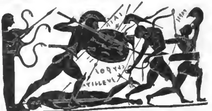


FIG. 9.—Fight over the body of Achilles. *Mon. d. Inst.* i. 51.

Athens.

The early history of vase-painting at Athens is complicated. It was only by degrees that the geometric style gave way to, or developed into, what is known as the black-figured style. It would seem that until the age of Pisistratus Athens was not notable in the world of art, and nothing could be ruder than some of the vases of Athens in the 7th century, for example that here figured, on one side of which are represented the winged Harpies (Fig. 11) and on the other Perseus accompanied by Athena flying from the pursuit of the Gorgons. This vase retains in its decoration some features of geometric style; but the lotus and rosette, the lion and sphinx, which appear on it, belong to the wave of Ionian influence. Although it involves a departure from strict chronological order, it will be well here to follow the course of development in pottery at Athens until the end of our period. Neighbouring cities, and especially Corinth, seem to have exercised a strong influence at Athens about the 7th century. We have even a class of vases called by archæologists Corintho-Attic. But in the course of the 6th century there is formed at Athens a distinct and marked black-figured style. The most remarkable example of this ware is the so-called François vase at Munich, by Clitias and Ergotimus, recently smashed by a madman, which contains, in most careful and precise rendering, a number of scenes from Greek myth. One of these vases is dated, since it bears the name and the figure of Callias in his chariot (*Mon. dell' Inst.* iii. 45), and this Callias won a victory at Olympia in 564 B.C. We engrave (Fig. 12) the reverse of a somewhat later black-figured vase of the Panathenaic class, given at Athens as a prize to the winner of a foot-race at the Panathenæa, with the foot-race (*stadion*) represented on it. A large number of Athenian vases of the 6th century have reached us, which bear the signatures of the potters who made, or the artists who painted them; lists of these will be found in the useful work of Klein, *Griechische Vasen mit Meistersignaturen*. The recent excavations on the acropolis have proved the erroneousness of the view, strongly maintained by Brunn, that the mass of the black-figured vases were of a late and imitative fabric. We now know that, with a few exceptions, vases of this class are not later than the early part of the 5th century. The same excavations have also proved that red-figured vase-painting, that is, vase-painting in which the background was blocked out with black, and the figures left in the natural colour of the vase (*Ency. Brit.* xix. p. 613) originated at Athens in the last quarter of the 6th century. We cannot here give a detailed account of the beautiful series of Athenian vases of this fabric. Many of the finest of them are in the British Museum. We engrave, as an example (Fig. 13), a group by the painter Pamphæus, representing Hercules wrestling with the river-monster Achelous, which belongs to the age of the Persian wars. The clear precision of the figures, the vigour of the grouping, the correctness of the anatomy, and the delicacy of the lines are all marks of distinction. The student of art will perhaps find the nearest parallel to these vase-pictures in Japanese drawings (*q.v.*). The Japanese artists are very inferior to the Greek in their love and understanding of the human body, but equal them in freshness and vigour of design. At the same time began the beautiful series of white vases made at Athens for the purpose of burial with the dead, and found in great quantities in the cemeteries of Athens, of Eretria, of Gela in Sicily, and of some other cities. They are well represented in the British Museum, and that of Oxford.

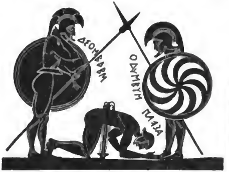


FIG. 10.—Suicide of Ajax. *Mus. Napoléon*, 66.

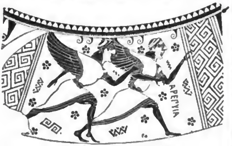


FIG. 11.—Harpies: Attic vase. *Arch. Zeit.* 1882, 9.

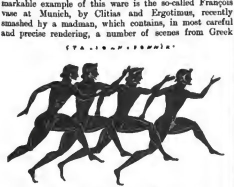


FIG. 12.—Foot-race: Panathenaic vase. *Mon. d. Inst.* x. 48 m.

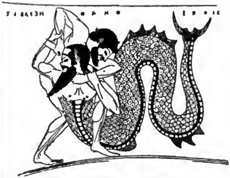


FIG. 13.—Herakles and Achelous. *Wiener Vorlegeblätter*, D. 6.

We now return to the early years of the 6th century, and proceed to trace, by the aid of recent discoveries, the rise of architecture and sculpture. The Greek temple in its character and form gives the clue to the whole character of Greek art. It is the abode of the deity, who is represented by his sacred image; and the flat surfaces of the temple offer a great field to the sculptor for the depicting of sacred legend. The process of discovery has emphasized the line which divides Ionian from Dorian architecture and art. We will speak first of the temples and the sculpture of Ionia. The Ionians were a people

Ionian temples.

far more susceptible than the Dorians to the influences of Oriental civilization. The dress, the art, and the luxury of Western Asia irresistibly attracted them, and we may suspect that Ionian workmen in the service of Asiatic rulers contributed largely to the adornment and the beauty of the palaces of Nineveh and Persepolis. Two of the great Ionian temples, dating from the 6th century, have been excavated in recent years. At Miletus, the labours of Messrs Rayet and Thomas have succeeded in discovering the plan of the great temple of Apollo, and even of the underground oracular chamber which lay beneath it, but the architectural fragments which they have brought to light belong all to a later construction; and the only figures which can be considered as belonging to the original temple destroyed by Darius are the dedicated seated statues, some of which, brought away by Sir Charles Newton, are now preserved at the British Museum. At Ephesus Mr Wood has been more successful, and has recovered considerable fragments of the temple of Artemis, to which, as Herodotus tells us, Crœsus presented many columns. The lower part of one of these columns, bearing figures in relief of early Ionian style, has been put together at the British Museum (Fig. 14); and remains of inscriptions recording the presentation by Crœsus are still to be traced. Reliefs from a cornice of somewhat later date are also to be found at the British Museum. Among the Ægean islands, Delos has furnished us with the most important remains of early art. French excavators have there found a very early statue of a woman dedicated by one Nicandra to Artemis (Fig. 16), a figure which may be instructively compared with another from Samos, dedicated to Hera by Cheramnes. The Delian statue is in shape like a flat beam; the Samian, which is headless, is like a round tree. The arms of the Delian figure are rigid to the sides; the Samian lady has one arm clasped to her breast (Fig. 15). A great improvement on these helpless and inexpressive figures is marked by another figure found at Delos, and connected, though without absolute certainty, with a basis recording the execution of the statue by Archermus and Micciades, two sculptors who stood, in the middle of the 6th century, at the head of a sculptural school at Chios. The representation (Fig. 17) is of a running or flying figure, having six wings, like the seraphim in the vision of Isaiah, and clad in long drapery. It may be a statue of Nike or Victory, who is said to have been represented in winged form by Archermus. The figure, with its neatness and precision of work, its expressive face and strong outlines, certainly marks great progress in the art of sculpture. When we examine the early sculpture of Athens, we find reason to think that the Chian school had great influence in that city in the days of Pisistratus.

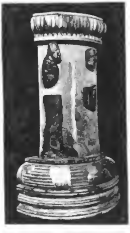


Fig. 14.—Sculptured pillar; Ephesus. Brit. Museum.

Athenian sculpture.

At Athens, in the age 650-480, we may trace two quite distinct periods of architecture and sculpture. In the earlier of the two periods, a rough limestone was used alike for the walls and the sculptural decoration of temples; in the later period it was superseded by marble, whether native or imported. Every visitor to the museum of the Athenian acropolis stands astonished at the recently recovered groups which decorated the pediments of Athenian temples before the age of Pisistratus—groups of large size, rudely cut in soft stone, of primitive workmanship, and painted with bright red, blue, and green, in a fashion which makes no attempt to follow nature, but only to produce a vivid result. The two largest in scale of these groups seem to have belonged to the pediments of the early 6th century temple of Athena. One represents the combat between Zeus and Hercules, who kneel back to back in the middle of the group, and their monstrous opponents Typhon and his wife Echidna; the other represents the struggle between Hercules and Triton in the presence of the serpent-footed Cecrops, first king of Attica. On other smaller pediments, perhaps belonging to shrines of Hercules and Dionysus, we have again conflicts of Hercules with Triton or with other monstrous foes. It is notable how fond the Athenian artists of this early time are of exaggerated

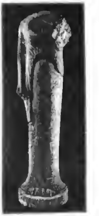


Fig. 15.—Figure dedicated to Hera: Paris.

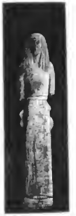


Fig. 16.—Figure dedicated to Artemis: Athens.

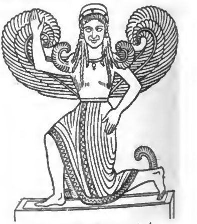


Fig. 17.—Nike of Chian school, restored.

muscles and of monstrous forms, which combine the limbs of men and of animals; the measure and moderation which mark developed Greek art are as completely absent as are skill in execution or power of grouping. We engrave (Fig. 18) a small pediment in which appears in relief the slaying of the Lernæan hydra by Hercules. The hero strikes at the many-headed water-snake, somewhat inappropriately, with his club. Iolaus, his usual companion, holds the reins of the chariot which awaits Hercules after his victory. On the extreme left a huge crab comes to the aid of the hydra.

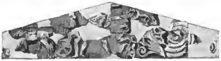


FIG. 18.—Athenian pediment: Herakles and Hydra. *Athen. Mittheil.* x. 237.

There can be little doubt that Athens owed its great start in art to the influence of the court of Pisistratus, at which artists of all kinds were welcome. We can trace a gradual transformation in sculpture, in which the influence of the Chian and other progressive schools of sculpture is visible, not only in the substitution of island marble for native stone, but in increased grace and truth to nature, in the toning down of glaring colour, and the appearance of taste in composition. A transition between the older and the newer is furnished by the well-known statue of the calf-bearer, an Athenian preparing to sacrifice a calf to the deities, which is made of marble of Hymettus, and in robust clumsiness of forms is not far removed from the limestone pediments. The sacrificer has been commonly spoken of as Hermes or Theseus, but he seems rather to be an ordinary human votary of the goddess.

In the time of Pisistratus or his sons a peristyle of columns was added to the old temple of Athena; and this necessitated the preparation of fresh pediments. These were of marble. In one of them was represented the battle between gods and giants; in the midst Athena herself striking at a prostrate foe (Fig. 19). In these figures no eye can fail to trace remarkable progress. On about the same level of art are the charming statues of votaresses of Athena, dedicated to her, which were set up in the latter half of the 6th century in the acropolis, whose graceful though conventional forms, and delicate colouring, make them one of the great attractions of the Acropolis Museum. We engrave (Fig. 20) a figure which, if it be rightly connected with the basis on which it stands, is the work of the sculptor Antenor, who was also author of a celebrated group representing the tyrant-slayers, Harmodius and Aristogeiton. To the same age belong many other votive reliefs of the acropolis, representing horsemen, scribes, and other votaries of Athena.

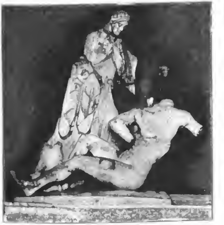


FIG. 19.—Pediment: Athena and giant. *Athen. Mittheil.* xxii. 3.

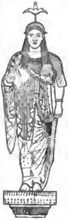


FIG. 20.—Figure of Antenor, restored.

Dorian sculpture.

From Athens we pass to the seats of Dorian art. And in doing so we find a complete change of character. In place of draped goddesses and female figures, we find nude male forms. In place of Ionian softness and elegance, we find hard rigid outlines, strong muscular development, a greater love of and faithfulness to the actual human form—the influence of the palæstra rather than of the harem. To the known series of archaic male figures, recent years have added many examples. We may especially mention a series of figures from the temple of Apollo Ptoos in Bœotia, probably representing the god himself. Still more noteworthy are two colossal nude figures of Apollo, remarkable both for force and for rudeness, found at Delphi, the inscriptions of which prove them to be the work of an Argive sculptor. From Crete we have acquired the upper part of a draped figure (Fig. 21), whether male or female is not certain, which should be an example of the early Dædalid school, whence the art of Peloponnesus was derived; but we can scarcely venture to treat it as a characteristic product of that school; rather the likeness to the dedication of Nicandra (Fig. 16) is striking.

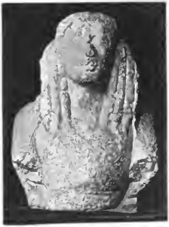


FIG. 21.—Bust from Crete.

Olympia. Sparta. Selinus.

Next in importance to Athens, as a find-spot for works of early Greek art, ranks Olympia. Olympia, however, did not suffer like Athens from sudden violence, and the explorations there have brought to light a continuous series of remains, beginning with the bronze tripods of the geometric age already mentioned, and ending at the barbarian invasions of the 4th century A.D. Notable among the 6th-century stone-sculpture of Olympia are the pediment of the treasury of the people of Megara, in which is represented a battle of gods and giants, and a huge rude head of Hera (Fig. 22), which seems to be part of the image worshipped in the Heræum. Its flatness and want of style are noteworthy. Among the temples of Greece proper the Heræum of Olympia stands almost alone for antiquity and interest, its chief rival, besides the temples of Athens, being the other temple of Hera at Argos. It appears to have been originally constructed of wood, for which stone was by slow degrees, part by part, substituted. In the time of Pausanias one of the pillars was still of oak, and at the present day the varying diameter of the columns and other structural irregularities bear witness to the process of constant renewal which must have taken place. The early small bronzes of Olympia form an important series, figures of deities standing or striding, warriors in their armour, athletes with exaggerated muscles, and women draped in the Ionian fashion, which did not become unpopular in Greece until after the Persian wars. Excavations at Sparta have not produced any sculptures admirable in an artistic way; but they have revealed interesting monuments belonging to the worship of ancestors, which seems in the conservative Dorian states of Greece to have been more strongly developed than elsewhere. On some of these stones, which doubtless belonged to the family cults of Sparta, we see the ancestor seated holding a wine-cup, accompanied by his faithful horse or dog; on some we see the ancestor and ancestress seated side by side (Fig. 23), ready to receive the gifts of their descendants, who appear in the corner of the relief on a much smaller scale. The male figure holds a wine-cup, in allusion to the libations of wine made at the tomb. The female figure holds her veil and the pomegranate, the recognized food of the dead. A huge serpent stands erect behind the pair. The style of these sculptures is as striking as the subjects; we see lean rigid forms with severe outline carved in a very low relief, the surface of which is not rounded but flat. The name of Selinus in Sicily, an early Megarian colony, has long been associated with some of the most curious of early sculptures, the metopes of ancient temples, representing the exploits of Hercules and of Perseus. Even more archaic metopes have in recent years been brought to light, one representing a seated sphinx, one the journey of Europa over the sea on the back of the amorous bull (Fig. 24), a pair of dolphins swimming beside her. In simplicity and in rudeness of work these reliefs remind us of the limestone pediments of Athens (Fig. 18), but yet they are of another and a severer style; the Ionian laxity is wanting.

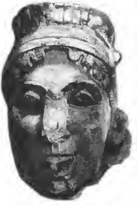


FIG. 22.—Head of Hera: Olympia.

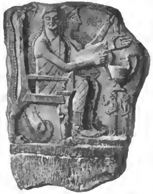


FIG. 23.—Spartan tombstone: Berlin.

Delphi.

When the results of the recent French excavations at Delphi are published, there is no doubt that we shall be able to add a new and important chapter to the history of 6th-century art. Of three treasure-houses, those of Sicyon, Cnidus, and Athens, the sculptural adornments have been in great part recovered. These sculptures form a series almost covering the century 570-470 B.C., and include representations of some myths of which we have hitherto had no example. Although the results of the excavations at Delphi are not yet published, we say here a few words as to the sculpture which has been discovered, leaving to the article DELPHI an account of the topography and the buildings of the sacred site. Of the archaic temple of Apollo, built as Herodotus tells us by the Alcmæonidæ of Athens, the only sculptural remains which have come down to us are some fragments of the pedimental figures. Of the treasuries which contained the offerings of the pious at Delphi, the most archaic of which there are remains is that belonging to the people of Sicyon. To it appertain a set of exceedingly primitive metopes. One represents Idas and the Dioscuri driving off cattle; another, the ship Argo; another, Europa on the bull; others merely animals, a ram or a boar. The treasury of the people of Cnidus (or perhaps Siphnos) is in style some half a century later. To it belongs a long frieze representing a variety of curious subjects: a battle, perhaps between Greeks and Trojans, with gods and goddesses looking on; a gigantomachy in which the figures of Poseidon, Athena, Hera, Apollo, Artemis, and Cybele can be made out, with their opponents, who are armed like Greek hoplites; Athena and Hercules in a chariot; the carrying off of the daughters of Leucippus by Castor and Pollux; Æolus holding the winds in sacks. The Cnidian treasury was restored in the French Exposition of 1900. The cornice of the front was supported by two archaic figures of Caryatids; a sphinx and two running Victories stand on the top of the pediment as acroteria, while within the pediment is represented the struggle between Apollo and Hercules for the possession of

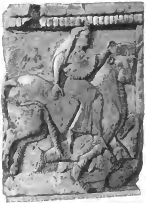


FIG. 24.—Metope; Europa on Bull: Palermo.

the Delphic tripod. The treasury of the Athenians, erected at the time of the Persian wars, was adorned with some metopes of singularly beautiful and clear-cut style, representing the deeds of Hercules and Theseus. Besides the decoration of the treasuries, and the charioteer mentioned below, there were found two very rude figures of Apollo naked, by Argive artists, a colossal sphinx on a lofty pillar dedicated by the people of Naxos, and other statues.

Period III. 480-400 B.C.

Olympia: Temple of Zeus.

On the age of the great early masters of sculpture, of Myron, Phidias, and Polycleitus, much light has been thrown in the last quarter of a century, partly by means of new excavation, but also, in a scarcely less degree, through the careful re-examination of known monuments. Under this period, the first place certainly belongs to the great temple of Zeus at Olympia. The statue by Phidias which once occupied the place of honour in that temple, and was regarded as the noblest monument of Greek religion, has of course disappeared, nor are we able with confidence to restore it. But the plan of the temple, its pavement, some of its architectural ornaments, remain. The marbles which occupied the pediments and the metopes of the temple have been in large part recovered, having been probably thrown down by earthquakes and gradually buried in the alluvial soil. The utmost ingenuity and science of the archæologists of Germany have been employed in the recovery of the composition of these groups; and although doubt remains as to the places of some figures, and their precise attitudes, yet we may fairly say that we know more about the sculpture of the Olympian temple of Zeus than about the sculpture of any other great Greek temple. The exact date of these sculptures is not certain, but we may with some confidence give them to the middle of the 5th century or a few years earlier. (In speaking of them we shall mostly follow the opinion of Dr. Treu, whose masterly work in vol. iii. of the great German publication on Olympia is a model of patience and of science.) In the eastern pediment (Fig. 25), as Pausanias tells us, were represented the preparations for the chariot-race between Œnomaus and Pelops, the result of which was to determine whether Pelops should find death, or a bride and a kingdom. In the midst, invisible to the contending heroes, stood Zeus the supreme arbiter. On one side of him stood Œnomaus with his wife Sterope, on the other Pelops and Hippodameia, the daughter of Œnomaus, whose position at once indicates that she is on the side of the new-comer, whatever her parents may feel. Next on either side are the four-horse chariots of the two competitors, that of Œnomaus in the charge of his perfidious groom Myrtilus, who contrived that it should break down in the running, that of Pelops tended by his grooms. At either end, where the pediment narrows to a point, reclines a river-god, at one end Alpheus, the chief stream of Olympia, at the other end his tributary Cladeus. Only one figure remains, not noticed in the careful description of Pausanias, the figure of a handmaid kneeling, perhaps one of the attendants of Sterope. Our engraving gives two conjectural restorations of the pediment, that of Treu and that of Kekule, which differ principally in the arrangement of the corners of the composition; the position of the central figures and of the chariots can scarcely be called in question. The moment chosen is one, not of action, but of expectancy, perhaps of preparation for sacrifice. The arrangement is undeniably stiff and formal, and in the figures we note none of the trained perfection of style which belongs to the sculptures of the Parthenon, an almost contemporary temple. Faults abound, alike in the rendering of drapery and in the representation of the human forms, and the sculptor has evidently trusted to the painter who was afterwards to colour his work, to remedy some of his clumsiness, or to make clear the ambiguous. Nevertheless there is in the whole a dignity, a sobriety, and a simplicity which reconcile us to the knowledge that this pediment was certainly regarded in antiquity as a noble work, fit to adorn even the palace of Zeus. In the other, the western, pediment (Fig. 26), the subject is the riot of the Centaurs when they attended the wedding of Pirithous in Thessaly, and, attempting to carry off the bride and her comrades, were slain by Pirithous and Theseus. In the midst of the pediment, invisible like Zeus in the eastern pediment, stands Apollo, while on either side of him Theseus and Pirithous attack the Centaurs with weapons hastily snatched. Our engraving gives two possible restorations. The monsters are in various attitudes of attempted violence, of combat and defeat; with each grapples one of the Lapith heroes in the endeavour to rob them of their prey. In the corners of the pediment recline female figures, perhaps attendant slaves, though the farthest pair may best be identified as local Thessalian nymphs, looking on with the calmness of divine superiority, yet not wholly unconcerned in what is going forward. Though the composition of the two pediments differs notably, the one bearing the impress of a parade-like repose, the other of an overstrained activity, yet the style and execution are the same in both, and the shortcomings must be attributed to the inferior skill of a local school of sculptors compared with those of Athens or of Ægina. It even appears likely that the designs also belong to a local school. Pausanias, it is true, tells us that the pediments were the work of Alcamenes, the pupil of Phidias, and of Pæonius, a sculptor of Thrace, respectively; but it is almost certain that he was misled by the local guides, who would naturally be anxious to connect the sculptures of their great temple with well-known names.

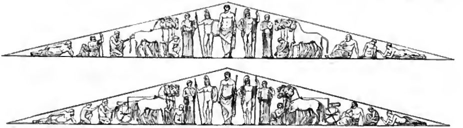


FIG. 25.—East pediment: Olympia. Two restorations.

The metopes of the temple are in the same style of art as the pediments, but the defects of awkwardness and want of mastery are less conspicuous, because the narrow limits of the metope exclude any elaborate grouping. The subjects are provided by the twelve labours of Hercules; the figures introduced in each metope are but two or at most three; and the action is simplified as much as possible. The example figured (Fig. 27) represents Hercules holding up the sky on a cushion, with the friendly aid of a Hesperid nymph, while Atlas, whom he has relieved of his usual burden, approaches, bringing the apples which it was the task of Hercules to procure.

Another of the fruits of the excavations of Olympia is

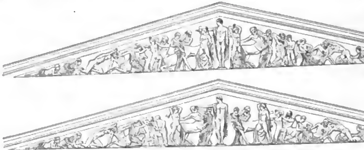


Fig. 26.—West pediment: Olympia. Two restorations.

the floating Victory by Pæonius, unfortunately faceless (Fig. 28), which was set up in all probability in memory of the victory of the Athenians and their Messenian allies at Sphacteria in 425 B.C. The inscription states that it was dedicated by the Messenians and people of Naupactus from the spoils of their enemies, but the name of the enemy is not mentioned in the inscription. The statue of Pæonius, which comes floating down through the air with drapery borne backward, is of a bold and innovating type, and we may trace its influence in many works of the next age.

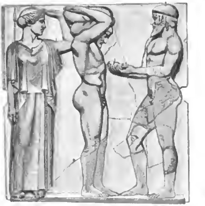


Fig. 27.—Metope: Olympia; restored. *Olympia*, iii. 45.

Delphic charioteer.

Among the discoveries at Delphi none is so striking and valuable to us as the life-size statue in bronze of a charioteer holding in his hand the reins. This has been shown by M. Homolle to be part of a chariot-group set up by Polyzalus, brother of Gelon and Hieron of Syracuse, in honour of a victory won in the chariot-race at the Pythian games at Delphi (Fig. 29). The charioteer is evidently a high-born youth, and is clad in the long chiton which was necessary to protect a driver of a chariot from the rush of air. The date would be about 480-470 B.C. Bronze groups representing victorious chariots with their drivers were among the noblest and most costly dedications of antiquity; the present figure is our only satisfactory representative of them. In style the figure is very notable, tall and slight beyond all contemporary examples. The contrast between the conventional decorousness of face and drapery and the lifelike accuracy of hands and feet is very striking, and indicates the clashing of various tendencies in art at the time when the great style was formed in Greece.

Phidias.

On the works of Phidias recent discovery has thrown some light, though but little which is direct. Much interest was aroused in 1880 by the finding at Athens of a marble reduction, a yard high, of the great Parthenos statue of Phidias (Fig. 30); but cooler consideration has forced us to allow that though the new statuette may be an authority as to some details of the Phidian statue, such as the decoration of the helmet, the attitude of the small figure of Victory, and the position of the snake, it is not to be implicitly trusted. The pillar which is introduced to support the weight of the figure of Victory seems to most artists a device unworthy of the genius of Phidias, though there is other evidence of its actual existence. In any case, this statuette cannot serve to give us any adequate notion of the great statue as a whole. Prof. Furtwängler has of late largely contributed to Phidian literature. He believes

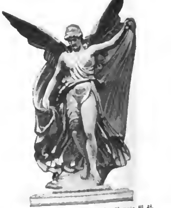


Fig. 28.—Nike of Paeonius; restored. *Olympia*, iii. 48.

himself to have discovered at Dresden copies of the Lemnian Athena, one of the most noted of the works of Phidias. The reasons for the identification are set forth in his *Masterpieces of Greek Sculpture.* In the same work and the later *Intermezzi* will be found very ingenious attempts to reconstruct and to explain the pediments of the Parthenon. But safer guides for the restoration of the wonderful sculptural decoration of the noblest of Greek temples will be found in Dr Sauer's careful researches into the evidence to be won on the spot from the existing backgrounds and bases of the pediments, from which one may judge of the positions and attitudes of some of the figures. And the finding of the head of Hebe in the Parthenon frieze is a most fortunate event, as giving us a well-preserved girl's head of the Phidian school.

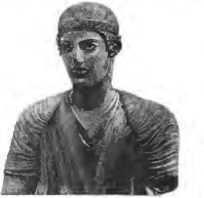


FIG. 29.—Bronze Charioteer: Delphi. *Memoires, Piot*, 1897, 16.

Polycleitus. To our knowledge of the art of Polycleitus many additions have been made. Among the bases discovered at Olympia, whence the statues had been removed, are three or four which bear the name of Polycleitus, and the definite evidence furnished by these bases as to the position of the feet of the statues which they once bore has enabled archæologists, especially Prof. Furtwängler, to identify copies of those statues among known works. Also newly discovered copies of Polycleitan works have made their appearance. At Delos there has been found a copy of the celebrated Diadumenus, which is of much finer work than the well-known statue in the British Museum from Vaison. The museum of Boston has secured a very beautiful statue of a young Hermes, who but for the wings on the temples might pass as a boy athlete of Polycleitan style (Fig. 31). In fact, instead of relying as regards the manner of Polycleitus on Roman copies of the Doryphorus and Diadumenus, we have quite a gallery of athletes, boys and men, who all claim relationship, nearer or more remote, to the school of the great Argive master. It might have been hoped that the recent excavations, made under the leadership of Prof. Waldstein at the Argive Heræum, would have enlightened us as to the style of Polycleitus. Just as the sculptures of the Parthenon are the best monument of Phidias, so it might seem likely that the sculptural decoration of the great temple which contained the Hera of Polycleitus would show us at large how his school worked in marble. Unfortunately the fragments of sculpture from the Heræum are few. The most remarkable is a female head, which may perhaps come from a pediment (Fig. 32). But archæologists are not in agreement whether it is in style Polycleitan, or whether it rather resembles in style Attic works. Other heads and some highly-finished fragments of bodies come apparently from the metopes of the same temple. (See also under ARGOS.)

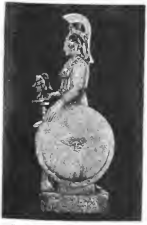


FIG. 30.—Statuette of Athena Parthenos.

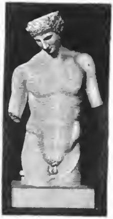


FIG. 31.—Torso of young Hermes: Boston.

Lycia. The series of known Lycian tombs, most of which were secured by Sir Charles Fellows for the British Museum, has been enriched through the acquisition by the museum of Vienna of the sculptured friezes which adorned a heroon near Gyeul Bashi. In the midst of the enclosure was a tomb, and the walls of the enclosure itself were adorned within and without with a great series of reliefs, mostly of mythologic purport. Many subjects which but rarely occur in early Greek art, the siege of Troy, the adventure of the Seven against Thebes, the carrying off of the daughters of Leucippus, Ulysses shooting down the Suitors, are here represented in detail. Prof. Benndorf, who has published these sculptures in an admirable volume, is disposed to see in them the influence of the Thasian painter Polygnotus. Any one can see their

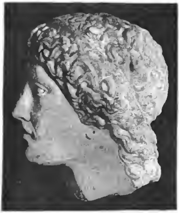


FIG. 32.—Female head: Heræum.

kinship to painting, and their subjects recur in some of the great frescoes painted by Polygnotus, Micon, and others for the Athenians. Like other Lycian sculptures, they contain non-Hellenic elements; in fact Lycia forms a link of the chain which extends from the wall-paintings of Assyria to works like the columns of Trajan and of Antoninus, but is not embodied in the more purely idealistic works of the highest Greek art. The date of the Vienna tomb is not much later than the middle of the 5th century. We engrave a small part of the frieze of this monument (Fig. 33). It will be seen that in this fragment there are two scenes, one directly above the other. In the upper line Ulysses, accompanied by his son Telemachus, is in the act of shooting the suitors, who are reclining at table in the midst of a feast; a cup-bearer, possibly Melanthius, is escaping by a door behind Ulysses. In the lower line is the central group of a frieze which represents the hunting of the Calydonian boar, which is represented, as is usual in the best time of Greek art, as an ordinary animal and no monster.

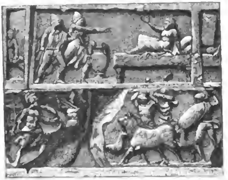


FIG. 33.—Odysseus and suitors; hunting of boar. *Heroon of Gyeul Bashi Trysa*, Pl. 7.

Perhaps earlier than 400 B.C. are certain groups found at Delos, which represent respectively the carrying away of the Athenian girl Oreithyia by the wind-god Boreas, and the carrying off of the hunter Cephalus by the Goddess of the Dawn. These fine groups, full of energy, but unfortunately fragmentary, are supposed to have once adorned the roof of the great temple of Apollo at Delos. They are now preserved at Athens, and are the best examples we possess of the groups which frequently stood on the tops of the pediments of Greek temples.

Portraits.

Archæologists are now beginning to pay more attention to an interesting branch of Greek art which had until recently been neglected, that of sculptured portraits. The known portraits of the 5th century now include Pericles, Herodotus, Thucydides, Anacreon, Sophocles, Euripides, Socrates, and others. As might be expected in a time when style in sculpture was so strongly pronounced, these portraits, unless later unfaithful copies, are notably ideal. They represent the great men whom they portray not in the spirit of realism. Details are neglected, expression is not elaborated; the sculptor tries to represent what is permanent in his subject rather than what is temporary. Hence these portraits do not seem to belong to a particular time of life; they only represent a man in the perfection of physical force and mental energy. And the race or type is clearly shown through individual traits. In some cases it is still disputed whether statues of this age represent deities or mortals, so notable are the repose and dignity which even human figures acquire under the hands of 5th-century masters. The Pericles after Cresilas in the British Museum, and the athlete-portraits of Polycleitus are good examples.

Athenian vases.

It is now generally held, in consequence of evidence furnished by tombs, that the 5th century saw the end of the making of vases on a great scale at Athens for export to Italy and Sicily. And in fact few things in the history of art are more remarkable than the rapidity with which vase-painting at Athens reached its highest point and passed it on the downward road. At the beginning of the century black-figured ware was scarcely out of fashion, and the masters of the severe red-figured style, Pamphæus, Epictetus, and their contemporaries, were in vogue. The schools of Euphronius, Hiero, and Duris belong to the age of the Persian wars. With the middle of the century the works of these makers are succeeded by unsigned vases of most beautiful design, some of them showing the influence of the great Thasian painter Polygnotus. In the later years of the century, when the empire of Athene was approaching its fall, drawing becomes laxer and more careless, and in the treatment of drapery we frequently note the ever-elaboration of folds, the want of simplicity, which begins to mark contemporary sculpture. Unfortunately we cannot here illustrate these changes of style, which can only be satisfactorily followed in the vase rooms of the British Museum, or other treasuries of Greek art.

Period IV. 400-320 B.C.

Praxiteles.

Until about the year 1880, our knowledge of the great Greek sculptors of the 4th century was derived mostly from the statements of ancient writers and from Roman copies, or what were supposed to be copies, of their works. We are now in a far more satisfactory position. We now possess an original work of Praxiteles, and sculptures executed under the immediate direction of, if not from the hand of, other great sculptors of that age—Scopas, Timotheus, Damophon, and others. Among all the discoveries made at Olympia, none has become so familiar to the artistic world as that of the Hermes of Praxiteles. It is the first time that we have become possessed of a first-rate Greek original by one of the greatest of sculptors. Hitherto almost all the statues in our museums have been either late copies of Greek works of art, or else the mere decorative sculpture of temples and tombs, which was by the ancients themselves but little regarded. But we can venture without misgiving to submit the new Hermes to the strictest examination, sure that in every line and touch we have the work of a great artist. This is more than we can say of any of the literary remains of antiquity — poem, play, or oration. Hermes is represented by the sculptor (Fig. 34) in the act of carrying the young child Dionysus to the nymphs who were charged with his rearing. On the journey he pauses and amuses himself by holding out to the child-god a bunch of grapes, and watching his eagerness to grasp them. To the modern eye the child is

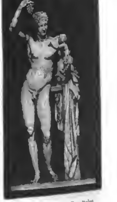


FIG. 34.—Hermes of Praxiteles, restored. *Olympia*, iii. 48.

not a success; only the latest art of Greece is at home in dealing with children. But the Hermes, strong without excessive muscular development, and graceful without leanness, is a model of physical formation, and his face expresses the perfection of health, natural endowment, and sweet nature. The statue can scarcely be called a work of religious art in the modern or Christian sense of the word religious, but from the Greek point of view it is religious, as embodying the result of the harmonious development of all human faculties and life in accordance with nature. The discovery of the Hermes has naturally set archæologists searching in the museums of Europe for other works which may from their likeness to it in various respects be set down as Praxitelean in character. In the case of many of the great sculptors of Greece—Cresilas, Silanion, Calamis, and others—it is of little use to search for copies of their works, since we have little really trustworthy evidence on which to base our inquiries. But in the case of Praxiteles we really stand on a safe level. Naturally it is impossible in these pages to give any sketch of the results, some almost certain, some very doubtful, of the researches of archæologists in quest of Praxitelean works. But we may mention a few works which have been claimed by good judges as coming from the master himself. Prof. Brunn claimed as work of Praxiteles a torso of a satyr in the Louvre, in scheme identical with the well-known satyr of the Capitol. Prof. Furtwängler puts in the same category a delicately beautiful head of Aphrodite at Petworth. And his translator, Mrs Strong, regards, with greater probability, the Aberdeen head of a young man in the British Museum as the actual work of Praxiteles. Certainly this last head does not suffer when placed beside the Olympian head of Hermes. At Mantinea has been found a basis whereon stood a group of Latona and her two children, Apollo and Artemis, made by Praxiteles. This base bears reliefs representing the musical contest of Apollo and Marsyas, with the Muses as spectators, reliefs very pleasing in style, and quite in the manner of Attic artists of the 4th century. But of course we must not ascribe them to the hand of Praxiteles himself; great sculptors did not themselves execute the reliefs which adorned temples and other monuments, but reserved them for their pupils. Yet the graceful figures of the Muses of Mantinea suggest how much was due to Praxiteles in determining the tone and character of Athenian art in relief in the 4th century. Exactly the same style which marks them belongs also to a mass of sepulchral monuments at Athens, and such works as the Sidonian sarcophagus of the Mourning Women, to be presently mentioned.

Scopas.

Excavation on the site of the temple of Athena Alea at Tegea has resulted in the recovery of works of the school of Scopas. Pausanias tells us that Scopas was the architect of the temple, and so important in the case of a Greek temple is the sculptural decoration, that we can scarcely doubt that the sculpture of the temple at Tegea was under the supervision of Scopas, especially as he was more noted as a sculptor than as an architect. In the pediments of the temple were represented two scenes from mythology, the hunting of the Calydonian boar and the combat between Achilles and Telephus. To one or other of these scenes belong two heads of local marble discovered on the spot, which are very striking from their extraordinary life and animation. Unfortunately both are so much injured that they can scarcely be made intelligible except by the help of restoration; we therefore engrave one of them, the helmeted head, as restored by a German sculptor (Fig. 35). The strong bony frame of this head, and its depth from front to back, are not less noteworthy than the parted lips and deeply set and strongly shaded eye; the latter features impart to the head a vividness of expression such as we have found in no previous work of Greek art, but which sets the key to the developments of art which take place in the Hellenistic age. The head of the Calydonian boar, which was found at the same time, is a curious work; the sculptor has transferred to the representation of a boar too much of his special style, and made it but little like an actual wild beast. Until these heads were found, Scopas was known to us, setting aside literary records, only as one of the sculptors who had worked at the Mausoleum. But it has now become possible to detect his style in many extant statues, such as the Meleager of the Vatican and the Hercules of the Lansdowne Gallery. It is also by no means unlikely that Scopas may have had a share in the carving of those sculptured pillars from the 4th-century temple of Artemis at Ephesus with which the spade of Mr Wood enriched the British Museum.

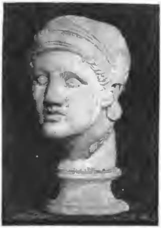


Fig. 35.—Head of warrior, restored: Tegea.

Timotheus.
Bryaxis.
Leochares.
Damophon.

The interesting precinct of Æsculapius at Epidaurus has furnished us with specimens of the style of an Athenian contemporary of Scopas, who worked with him on the Mausoleum. An inscription which records the sums spent on the temple of the Physician-god, informs us that the models for the sculptures of the pediments, and one set of acroteria or roof adornments, were the work of Timotheus. Of the pedimental figures and the acroteria considerable fragments have been recovered, and we may with confidence assume that the models for these at all events were by Timotheus. It is strange that the unsatisfactory arrangement whereby a noted sculptor makes models and some local workman the figures enlarged from those models, should have been tolerated by so artistic a people as the Greeks. The subjects of the pediments appear to have been the common ones of battles between Greek and Amazon and between Lapith and Centaur. We possess fragments of some of the Amazon figures, one of which is here engraved (Fig. 36) striking downwards at an enemy. Their attitudes are vigorous and alert; but the work shows no delicacy of detail. Figures of Nereids riding on horses, which were found on the same site, may very probably be roof ornaments (acroteria) of the temple. We have also several figures of Victory, which probably were acroteria on some smaller temple, perhaps that of Artemis. A base found at Athens, sculptured with figures of horsemen in relief, bears the name of Bryaxis, and was probably made by a pupil of his. Probable conjecture assigns to Leochares the originals copied in the Ganymedes of the Vatican, borne aloft by an eagle, and the noble statue of Alexander the Great at Munich. Thus we may fairly say that we are now acquainted with the work of all the great sculptors who worked on the Mausoleum—Scopas, Bryaxis, Leochares, and Timotheus; and are in a far more advantageous position than were the archæologists of 1880 for determining the artistic problems connected with that noblest of ancient tombs. As regards the plan and architecture of the Mausoleum, contributions have been made by Mr Oldfield (*Archæologia*, 1895-97), and Dr Adler (*Das Mausoleum*); but no generally accepted conclusion has been reached. Another great 4th-century artist, Damophon of Messene, is now known to us from his actual works. He set up in the shrine of the *Mistress* (Despœna) at Lycosura in Arcadia a great group of figures consisting of Despœna, Demeter, Artemis, and the Titan Anytus. Three colossal heads found on the spot probably belong to the three last-mentioned deities. We engrave the head of Anytus, with wild disordered hair and turbulent expression (Fig. 37). Dr Dorpfeld has argued, on architectural grounds, that shrine and images alike must be given to a later time than the 4th century; and in consequence some archæologists are of opinion that Damophon must have worked in the Roman age, or at all events in Hellenistic times. It is difficult to accept this view, because Damophon is spoken of by Pausanias as author of a statue of the City of Thebes, and of many works in the cities established in Peloponnesus at the time of the Theban hegemony early in the 4th century. We prefer to retain Damophon as a sculptor of the 4th century, and even find no great difficulty in reconciling the style of his works with that date.

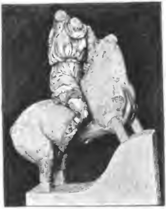


Fig. 36.—Amazon from Epidaurus.

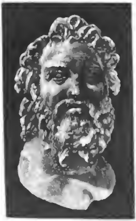


Fig. 37.—Head of Anytus; Lycosura.

Sarcophagi of Sidon

This may be the most appropriate place for mentioning the remarkable find made at Sidon in 1886 of a number of sarcophagi, which once doubtless contained the remains of kings of Sidon. They are now in the museum of Constantinople, and are admirably published by Hamdy Bey and T. Reinach (*Une nécropole royale à Sidon*, 1892-96). The sarcophagi in date cover a considerable period. The earlier are made on Egyptian models, the covers shaped roughly in the form of a human body or mummy. The later, however, are Greek in form, and are clearly the work of skilled Greek sculptors, who seem to have been employed by the grandees of Phœnicia in the adornment of their last resting-places. Four of these sarcophagi in particular claim attention, and in fact present us with examples of Greek art of the 5th and 4th centuries in several of its aspects. To the 5th century belong the tomb of the Satrap, the reliefs of which bring before us the activities and glories of some unknown king, and the Lycian sarcophagus, so called from its form, which resembles that of tombs found in Lycia, and which is also adorned with reliefs which have reference to the past deeds of the hero buried in the tomb, though these deeds are represented, not in the Oriental manner directly, but in the Greek manner, clad in mythological forms. To the 4th century belong two other sarcophagi. One of these is called the Tomb of the Mourning Women. On all sides of it alike are ranged a series of beautiful female figures, separated by Ionic pillars, each in a somewhat different attitude, though all attitudes denoting grief (Fig. 38). The pediments at the ends of the cover are also closely connected with the mourning for the loss of a friend and protector, which is the theme of the whole decoration of the sarcophagus. We see depicted in them the telling of the news of the death, with the results in the mournful attitude of the seated figures. The mourning women must be taken, not as the representation of any persons in particular, but generally as the expression of the feeling of a city. Such figures are familiar to us in the art of the second Attic school; we could easily find parallels to the sarcophagus among the 4th-century sepulchral reliefs of Athens. We can scarcely be mistaken in attributing the workmanship of this beautiful sarcophagus to some sculptor trained in the school of Praxiteles. And it is a conjecture full of probability that it once contained the body of Strato, king of Sidon, who ruled about 380 B.C., and who was *proxenos* or public friend of the Athenians.

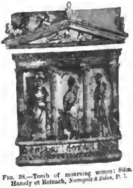


Fig. 38.—Tomb of mourning women: Sidon. Hamdy et Reinach, *Nécropole à Sidon*, Pl. 7.

More celebrated is the astonishing tomb called that of Alexander, though there can be no doubt that, although it commemorates the victories and exploits of Alexander, it was made not to hold his remains, but those of some ruler of Sidon who was high in his favour. Among all the monuments of antiquity which have come down to us none is more admirable than this, and none more characteristic of the Greek genius. We represent, in two lines, the composition which adorned one of the sides of this sarcophagus. It represents a victory of Alexander, probably that of Issus (Fig. 39). On the left we see the Macedonian king charging the Persian horse, on the right his general Parmenio, and in the midst a younger officer, perhaps Cleitus. Mingled with the chiefs are foot-soldiers, Greek and Macedonian, with whom the Persians are mingled in unequal fray. What most strikes the modern eye is the remarkable freshness and force of the action and the attitudes. Those, however, who have seen the originals have been specially impressed with the colouring, whereof of course our engraving gives no hint, but which is applied to the whole surface of the relief with equal skill and delicacy. There are other features in the relief on which a Greek eye would have dwelt with special pleasure—the exceedingly careful symmetry of the whole, the balancing of figure against figure, the skill with which the result of the battle is hinted rather than depicted. The composition is one in which the most careful planning and the most precise calculation are mingled with freedom of hand and expressiveness in detail. The faces in particular show more expression than would be tolerated in art of the previous century. We are unable as yet to assign an author or even a school to the sculptor of this sarcophagus; he comes to us as a new and striking phenomenon in the history of ancient art. The reliefs which adorn the other sides of the sarcophagus are almost equally interesting. On one side we see Alexander again, in the company of a Persian noble, hunting a lion. The short sides also show us scenes of fighting and hunting. In fact it can scarcely be doubted that if we had but a clue to the interpretation of the reliefs, they would be found to embody historic events of the end of the 4th century. There are but a few other works of art, such as the Bayeux tapestry and the Column of Trajan, which bring contemporary history so vividly before our eyes. The battles with the Persians represented in some of the sculpture of the Parthenon and the temple of Nike at Athens are treated conventionally and with no attempt at realism; but here the ideal and the actual are blended into a work of consummate art, which is at the same time, to those who can read the language of Greek art, a historic record. The portraits of Alexander the Great which appear on this sarcophagus are almost contemporary, and the most authentic likenesses of him which we possess. The great Macedonian exercised so strong an influence on contemporary art, that a multitude of heads of the age, both of gods and men, and even the portraits of his successors, show traces of his type. All the extant portraits of the king are put together, in a pamphlet by Dr. Koepp.

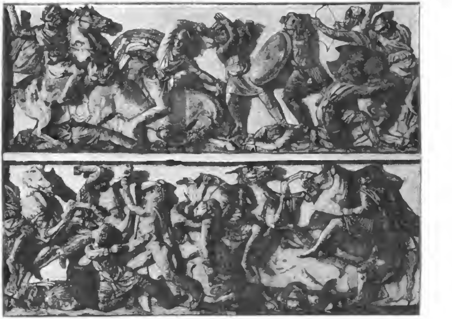


FIG. 39. Battle of Issus—sarcophagus from Sidon. Hamdy et Reinach, *Necropole à Sidon*, Pl. 30.

Period V. *After* B.C. 320.

Altar of Pergamon.

Our knowledge of the art of the age succeeding Alexander the Great, the age now commonly by historians called the Hellenistic, has received a great accession since 1875 through the systematic labours directed by the German Archæological Institute, which have resulted in recovering the remains of Pergamon, the fortress-city which was the capital of the dynasty of the Philetæri. Among the ancient buildings of Pergamon none was more ambitious in scale and striking in execution than the great altar used for sacrifice to Zeus, a monument supposed to be referred to in the phrase of the Apocalypse "where Satan's throne is." This altar, like many great sacrificial altars of later Greece, was a vast erection to which one mounted by many steps, and its outside was adorned with a frieze which represented on a gigantic scale, in the style of the 2nd century B.C., the battle between the Gods and the Giants. This enormous frieze is now one of the treasures of the Royal Museums of Berlin, and it cannot fail to impress visitors by the size of the figures, the energy of the action, and the strong vein of sentiment which pervades the whole, giving it a certain air of modernity, though the subject is strange to the Christian world. In early Greek art the Giants where they oppose the Gods are represented as men armed in full panoply, "in shining armour, holding long spears in their hands," to use the phrase in which Hesiod describes them. But in the Pergamene frieze the Giants are strange compounds, having the heads and bodies of wild and fierce barbarians, sometimes also human legs, but sometimes in the place of legs two long serpents, the heads of which take with the Giants themselves a share in the battle. Sometimes also they are winged. The Gods appear in the forms which had been gradually made for them in the course of Greek history, but they are usually accompanied by the animals sacred to them in cultus, between which and the serpent-feet of the Giants a weird combat goes on. We can conjecture the source whence the Pergamene artist derived the shaggy hair, the fierce expression, the huge muscles of his Giants (Fig. 40); probably these features came originally from the Galatians, who at the time had settled in Asia Minor, and were spreading the terror of their name and the report of their savage devastations through all Asia Minor. The victory over the Giants clearly stands for the victory of Greek civilization over Gallic barbarism; and this meaning is made more emphatic because the Gods are obviously inferior in physical force to their opponents, indeed, a large proportion of the divine combatants are goddesses. Yet everywhere the Giants are overthrown, writhing in pain on the ground, or transfixed by the weapons of their opponents; everywhere the Gods are victorious, yet in the victory retain much of their divine calm. The piecing together of the frieze at Berlin has been a labour of many years, and is even yet incomplete. We still await a final and monumental publication of it. Some of the groups, however, have become familiar to students from photographs, especially the group which represents Zeus slaying his enemies with thunderbolts, and the group wherein Athena seizes by the hair an overthrown opponent, who is winged, while Victory runs to crown her, and beneath is seen Gaia, the earth-goddess who is the mother of the Giants, rising out of the ground, and mourning over her vanquished and tortured children. Another and smaller frieze which also decorated the altar-place gives us scenes from the history of Telephus, who opposed the landing of the army of Agamemnon in Asia Minor and was overthrown by Achilles. This frieze, which is quite fragmentary, is put together by Dr Schneider in the *Jahrbuch* of the German Archæological Institute for 1900.

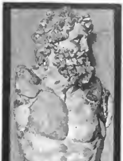


FIG. 40.—Giant from great altar: Pergamon.

Since the Renascence Rome has continually produced a crop of works of Greek art of all periods, partly originals brought from Greece by conquering generals, partly copies made by Greek artists for wealthy Roman amateurs. The extensive excavations and alterations which have taken place at Rome in recent years have been very fruitful in this way; the results may be found partly in the palace of the Conservatori on the Capitol, partly in the new museum of the Terme. Among recently found statues none excel in interest some bronzes of large size dating from the Hellenistic age. We engrave (Fig. 41) the figure of a seated boxer, in scale somewhat exceeding life. Attitude and gesture are expressive. Evidently the boxer has fought already, and is awaiting a further conflict. His face is cut and swollen; on his hands are the terrible cæstus, here made of leather, and not loaded with iron, like the cæstus described by Virgil. The figure is of astounding force; but though the face is brutal and the expression savage, in the sweep of the limbs there is nobility, even ideal beauty. To the last the Greek artist could not set aside his admiration for physical perfection. Another bronze figure of more than life-size is that of a king of the Hellenistic age standing leaning on a spear. He is absolutely nude, like the athletes of Polycleitus. Another large bronze presents us with a Hellenistic type of Dionysus.

Rome.

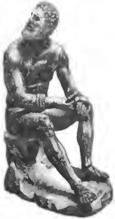


FIG. 41.—Bronze boxer: Rome. Ant. Denkmaler des Inst. Pl. 4.

Sculpture of the Roman age has not in recent years been discovered to the same extent. We have gained rather by a closer and more exact study of monuments already known than from the discovery of fresh monuments. The columns of Trajan and of Antoninus have been re-published in a series of excellent photographic plates. Many provincial monuments, such as the Roman tomb at S. Rémy, the arch of Beneventum, the monument of Adam Klissi, have been more carefully published. Many additions have been made to our already vast series of Roman portraits, and the gigantic publication of Arndt on Greek and Roman portraits has for the first time put together the necessary materials for a more satisfactory arrangement of portraits, as well as for their identification. Unfortunately, at present the great mass of portraits, both Greek and Roman, have to be labelled "unknown person." In Italian and other museums it has been the custom to assign names to portraits for reasons which will not bear investigation. Bernoulli's *Römische Ikonographie* is, however, a scientific work; a similar work by Bernoulli on Greek iconography is now in course of publication: the book of Visconti is quite out of date and untrustworthy.

The most important discovery at Pompeii, during the last quarter of a century, has been that of the Domus Vettiorum, a house whereof the walls are adorned with an unusually important series of paintings, partly scenes from Greek mythology, partly scenes which give us glimpses of daily life. Among the former are Achilles in Scyros, the punishment of Dirce, the death of Pentheus, Dedalus and Pasiphaë. Among the latter we especially note the series of scenes in which Cupids are represented as engaged in various kinds of manufacture and commerce, a Hellenistic fashion of introducing the actual in a manner not too literal. Other paintings found at Rome range with or even excel those of Pompeii, notably the remarkable wall-paintings representing artificial gardens with shrubs and flowers, which have been found at Prima Porta.

The whole subject of Roman art has been recently discussed by Prof. Wickhoff of Vienna in an essay translated into English by Mrs. Strong. This writer claims for the art of Italy and of Rome greater independence and more importance than had been conceded to it by other writers. He regards the art of the Augustan age as the last efflorescence of the Greek creative genius, which at that time had passed by a reaction against the strained and theatrical tendencies of the Pergamene school to a somewhat dry and insipid naturalism, a style of which the portraits of Augustus, the reliefs of the Ara Pacis at Rome, and some of the paintings of Pompeii are good examples. Against the jejuneness of this art the national spirit of Italy, which had for long been expressed in a series of portraits, lifelike if somewhat course, revolted towards the end of the 1st century. The result is to be observed in the portraits of the Flavian age, which are far more vivid than those of the Cæsars, as well as in the remarkable reliefs of the arch of Titus and the column of Trajan. In this national Roman art, Prof. Wickhoff does not hesitate to see illusionism, as opposed to the typical art of Greece, and the naturalism of the early empire. Its chief features are the attempt to produce a vivid and individual effect, often worked by very simple means, and the continuous method of representation of events, a method according to which successive scenes of a transaction follow one another without any separation, and the actors appear again and again in the same relief. Thus Trajan appears eighty-five times over in the continuous scroll of relief which adorns his column; and on Roman sarcophagi the successive scenes of a mythical tale follow one another without division. It was, according to Prof. Wickhoff, from illusionist Roman art that the earliest Christian art took its origin; hence its effects lasted far on into the Middle Ages. It is evidently impossible in this place to criticize these novel views; their importance lies in the fact that they are perhaps the first attempt to set forth the course of Roman art as a valuable development rather than as a mere process of degeneration; but most readers will think that Dr Wickhoff overvalues Roman, and undervalues Greek art. (P. G.)

Archangel. See ARKHANGELSK.

Archbald, a borough of Lackawanna county, Pennsylvania, U.S.A., in the anthracite coal region in the northeastern part of the state, on several railways. Population (1890), 4032; (1900), 5396.

Arches, Court of the.—The court of the Arches is the court of appeal of the archbishop of Canterbury as metropolitan of the province of Canterbury from all the consistory and commissary courts in the province, and its decisions are in most cases appealable to the judicial committee of the Privy Council. (See *Ency. Brit.* vol. ii. p. 378.) The judge (known as the dean of the Arches) was until 1874 appointed by the archbishop of Canterbury by patent which, when confirmed by the dean and chapter of Canterbury, conferred the office for the life of the holder. He took the oaths of office required by the 127th canon. But by the Public Worship Regulation Act, 1874 (37 and 38 Vict. c. 85), the two archbishops were empowered, subject to the approval of the sovereign by sign-manual, from time to time to appoint a judge for the purpose of exercising jurisdiction under that Act, and it was enacted (sec. 7) that on a vacancy occurring in the office of dean of the Arches, the judge so to be appointed should become *ex officio* dean of the Arches. In this way the late Lord Penzance became dean on the retirement of Sir Robert Phillimore in 1875. Lord Penzance received in 1878 a supplemental patent as dean from Archbishop Tait, but did not otherwise fulfil the conditions observed on the appointment of his predecessors. On Lord Penzance's retirement in 1899, his successor, Sir Arthur Charles, was appointed dean by patent from the archbishop of Canterbury, and he took the oaths of office according to the practice before the Public Worship Regulation Act. He was subsequently and separately appointed judge under that Act.

Under the Clergy Discipline Act, 1892 (55 and 56 Vict. c. 32, sec. 4) an appeal lies from the judgment of a consistory court under that Act, in respect of fact by leave of the appellate court, and in respect of law without leave, to either the court of the Arches or the judicial committee of the Privy Council at the option of the appellant. Under the Benefices Act, 1898 (61 and 62 Vict. c. 48, sec. 3 (4)), the official principal of the archbishop is required to institute a presentee to a benefice if the tribunal constituted under that Act decides that there is no valid ground for refusing institution and the bishop of the diocese notwithstanding fails to institute him. For many years past there has been but little business in the court of Arches. On the rare occasions when a sitting of the court is necessary, it is held in the library of Lambeth Palace, or at the Church House. (L. T. D.)

ARCHITECTURE.

I. MODERN.

BOTH in England and in the United States, the last quarter of the 19th century was a period of unusual interest and activity in architectural development. While other nations have been content to carry on their architecture, for the most part, on the old scholastic lines which had been prevalent since the Renaissance, in the two countries named there has been manifest a spirit of unrest, of critical inquiry into the basis and objects of architecture; an aspiration to make new and original creations in or applications of the art, without example in any other period in the modern history of architecture. In England, the "note"—heard with increasing shrillness of *crescendo* towards the very last year of the century—has been the cry for originality, for throwing off the trammels of the past, for rendering architecture more truly a direct expression of the conditions of practical requirement and of structure. This was no doubt to some extent the effect of a reaction. During the greater part of the century architectural strength had been spent in revivals of past styles. First came the Greek revival, of which the best result was St George's Hall at Liverpool, and the worst the formation of the tower of St Pancras Church in London by piling three Greek temples or shrines one upon another. Then followed the Gothic revival, which gained an immense impetus from the fact that it coincided with the spiritual and ecclesiological revival of the English church—and indeed it is rather difficult to apportion cause and effect between the spiritual and the architectural revival. At all events, *donec templa refecimus* was the motto of the day. The land was covered with modern mediæval churches, and with Gothic town halls and residences; and the business of restoring cathedrals was carried to an extent which deprived some of them of most of their value, and which an after generation has had to regret when regret was unavailing.

Gothic.

It was in 1869, just before the period we are here dealing with, that the great competition for the London Law Courts took place; and Street's building, completed a few years afterwards, was the last great national building erected in the revived Gothic style; as was observed shortly after its completion, it was "the grave of modern Gothic architecture," at least as regarded important secular buildings. Churches indeed, up to the close of the century, continued to be built, for the most part, in revived Gothic; but this was owing to special clerical influence, which saw in Gothic a style specially consecrated to church architecture, and would be satisfied, as a rule, with nothing else. Efforts have been made by architects to modify the mediæval church plan into something more practically suited to modern congregational worship, by a system of reducing the side aisles to mere narrow passages for access to the seats, thus retaining the architectural effect of the arcade, while keeping it out of the way of the seated congregation; and there have been occasional reversions to the ancient Christian basilica type of plan, or sometimes, as in the church in Davies Street, London, attempts to treat a church in a manner entirely independent of architectural precedent; but in the main, Gothic has continued to rule for churches. Apart from this special class of building, however, revived Gothic began to droop during the 'seventies. All had been copied that could be copied, and the result, to the architectural mind, was not satisfaction but satiety. Gothic began to be regarded as "played out." The immediate result, however, was not an organized attempt to think for ourselves, and make our own style, but a recourse to another class of precedent, represented in the type of early 18th-century building which became known as "Queen Anne," and which, like Gothic before it, was now to be recommended as "essentially English," as in fact it is. It can hardly, however, be called an architectural style; it would have no right to figure in any work illustrating the great architectural styles of the world. It was, in fact, the last dying phase of the English Renaissance; the architecture of the classic order reduced to a threadbare condition, treated very simply and in plain materials, in many cases shorn of its columnar features, and reflecting faithfully enough the prim rationalistic taste in literature and art of the England of the 18th century. Though not to be dignified as a *style*, it was, however, a recognizable and consistent *manner* in building; it made extensive use of brick, a material inexpensive and at the same time very well suited to the English climate and atmosphere; and it was generally carried out in very solid proportions, and with very good workmanship. To a generation tired of imitating a great style at second hand, this unpretending and simple model was a welcome relief, and led to the erection of a considerable number of modern buildings, dwelling-houses especially, the obvious aim of which was to look as like 18th-century buildings as possible. A typical example is the large London house by Mr Norman Shaw, at the corner of Queen's Gate and Imperial Institute Road. The Chelsea Vestry Hall (Fig. 1), by Mr. Brydon, is a good example of a public building in the revived Queen Anne style.

"Queen Anne."

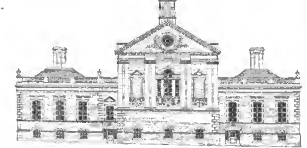


FIG. 1.—Chelsea Vestry Hall—Example of Modern "Queen Anne." (*J. M. Brydon.*)

A change of front from copying a great style like the mediæval, to copying what is at best a bastard one, if a style at all, might not seem to promise very much for the emancipation of modern architecture; yet there turned out to be one element of progress in it, resting on the fact that the comparatively simple detail of the 18th-century buildings formed a kind of vernacular of building workmanship, which could be comprehended and carried out by good artisans as a recognized tradition. Now, to reduce architecture to good sound building and good workmanship seemed to promise at any rate a better basis to work upon than the mere imitation of classic or mediæval detail; it might conceivably furnish a new starting-point. This was the element of life in the Queen Anne revival, and it had, as we shall see, an influence beyond the circle of the special revivers of the style. But almost concurrently with, or following hard upon, the "Queen Anne" movement arose the idea of a modern architecture, founded on a free and unfettered treatment of the materials of our earlier Renaissance architecture, as illustrated in buildings of the Stuart period. This new ideal was styled "free classic," and it gave the prevailing tone to English architecture for the last fifteen years of the century, though it had its commencement in certain characteristic buildings a good many years earlier than that. In 1873, for instance, there arose a comparatively small front in Leadenhall Street, under the name of "New Zealand Chambers" (Fig. 2), and designed by Mr Norman Shaw, R.A., which excited more attention, and had more influence on contemporary architecture than many a building of far greater size and importance. This represented the playful and picturesque possibilities of "free classic." Its more restrained and refined achievements were early exemplified in Mr Bodley's design for the front of the London School Board Offices on the Thames Embankment;[1] a comparatively small building which also exercised a considerable influence. There were no details here, however, but what could be found in Stuart (or, as it is more often called, Jacobean) architecture, but the building, and the prominence of its architect's name, helped to draw attention to the possibilities of the style, and it has been discovered that free classic is

"Free classic."

---

[1] The western half of the present front; the design was duplicated afterwards, on the extension of the building, but Mr Bodley originated it.

susceptible of a great deal of original treatment based on Renaissance elements. As an example, we may cite a street front built some twenty years later by another academician-architect; viz., the offices of the Chartered Accountants in the City, by Mr J. Belcher, A.R.A. More dignified and more monumental than New Zealand Chambers, more original than the School Board Offices, this front contains some details and a general treatment which may be said to be absolutely new; it affords another example of a piece of street architecture which attracted a great deal of attention, and has had an effect quite disproportionate to its size and importance as a building; and it gives a general measure of the progress of the "free classic" idea. During the last decade of the century "free classic" has been almost the recognized style in English architecture, and has been illustrated in many town halls and other large and important buildings, among which the Imperial Institute is a prominent example.

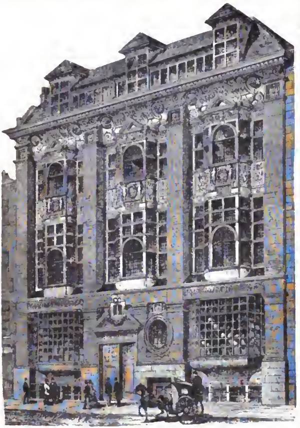


FIG. 2.—New Zealand Chambers. (*R. Norman Shaw, R.A.*)

The allied Arts. Concurrently with this tendency towards a free classic style there has arisen another movement which has had a considerable influence already on English architecture, and which will probably have a further influence in the future, viz., an increased perception of the importance of decorative arts—sculpture, painting, mosaic, &c.—in alliance with architecture, and of the architect and the decorative artist working together and in harmony. This is no more than what has long been understood and acted on in France, but it has been a new light to modern English architecture, in which, until a comparatively recent period, decorative painting was hardly thought of, and decorative sculpture, where it was introduced, was too often, or indeed generally, the mere work of some trading firm of masons. But of late years sculpture has taken a far more prominent place in connexion with architecture; it has become a habit with the best architects to rely largely on the introduction of appropriate and symbolic sculpture to add to the interest of their buildings, and to associate with them eminent sculptors, who, instead of regarding their work only in the light of isolated statues or groups for the exhibition room and the art gallery, are willing to give their best efforts to produce high-class sculpture for the decoration of an architectural design which forms the framework to it.

The craftsmanship ideal. Notice should be taken, however, of another movement in English architecture during the closing years of the 19th century. Reference has already been made to one idea which prompted the culture of the "Queen Anne" type of architecture: that it presented a simple vernacular of construction and detail, in which solid workmanship was a more prominent element than elaboration of what is known as architectural style. To a small group of clever and enthusiastic architects of the younger generation it appeared that this idea of reducing architecture to the common-sense of construction might be carried still further; that as all the revivals of styles since the Renaissance had failed to give permanent satisfaction and had tended to reduce architecture to a learned imitation of the work of former epochs, the real chance for giving life to architecture as a modern art was to throw aside all the conventionally accepted insignia of architectural style—columns, pilasters, cornices, buttresses, &c.—and to begin over again with mere workmanship—wall-building and carpentry—and trust that in process of time a new decorative detail would be evolved, indebted to no precedent. The building artisans, in fact, were collectively to take the place of the architect, and the form of the building to be evolved by a natural process of growth. This was a favourite idea also with William Morris, who insisted that mediæval art—the only art which he recognized as of any value (Greek, Roman, and Renaissance being alike contemptible in his eyes)—was essentially an art of the people, and that in fact it was the modern architects who stood in the way of our having a genuine architecture of the 19th century. Considering how much of merely formal, conventional, and soulless architecture has been produced in our time under the guidance of the professional architect, it is impossible to deny that there is an element of truth in this reasoning; at all events, that there have been a good many modern architects who have done more harm than good to architecture. But when we come to follow out this reasoning to its logical results, it is obvious that there are serious flaws in it. Morris's idea that mediæval architecture alone was worthy the name, we may, of course, dismiss at once; it was the prejudice of a man of genius whose sympathies, both in matters social and artistic, were narrow. Nor can we regard the mediæval cathedrals as artisan's architecture. The name of "architect" may have been unknown, but that the personage was present in some guise, the very individuality and variety of our English cathedrals attest. Peterborough front was no mere mason's conception.

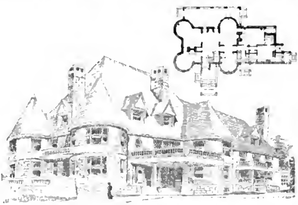


FIG. 3.—American Type of Country-house Architecture.

And when we come to consider modern conditions of building, it is perfectly obvious that with the complicated practical requirements of modern building, in regard to planning, heating, ventilation, &c., the planning of the whole in a complete set of drawings, before the building is begun, is an absolute necessity. We are no longer in mediæval times; modern conditions require the modern architect. The real cause of failure, as far as modern architecture is a failure, lies partly in the fact that it is practised too much as a profession or business, too little as an art; partly in the deadening effect of public indifference to art in Britain. If the public really desired great and impressive works of architecture they would have them; but neither the British public, nor its mouthpiece the Government, care anything about it. Their highest ambition is to get convenient and economical buildings. And as to the theory of the new school, that we should throw overboard all precedent in architectural detail, that is intellectually impossible. We are not made so that we can invent everything *de novo*, or escape the effect on our minds of what has preceded us; the attempt can only lead to baldness or eccentricity. Every great style of architecture of the past has, in fact, been evolved from the detail of preceding styles; and some of the ablest and most earnest architects of the present day are, indeed, urging the desirability of clinging to traditional forms in regard to detail, as a means of maintaining the continuity of the art. This does not by any means imply the absence of original architecture; there is scope for endless origination in the plan and the general design of a building. The Westminster Houses of Parliament (one of the greatest buildings of modern times), is a prominent example. The detail is a reproduction of Tudor detail, forced upon the architect by order of the Government; the plan and the general conception are absolutely original, and resemble those of no other pre-existing building in the world.

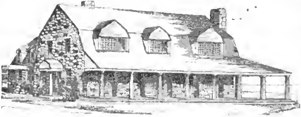


FIG. 4.—American Seaside Villa. (*Bruce Price.*)

In the United States.

It is necessary to take account of all these movements of opinion and principle in English architecture to appreciate properly its position and prospects at the time with which we are here dealing. Turning now from England to the United States, which, as already observed, is the only other important country in which there has been a general new movement in architecture, we find, singular to say, that the course of development has in America been almost the reverse of what has taken place in England. The rapidity of architectural development in America, it may be observed, during the last quarter of a century, has been something astonishing; there is no parallel to it anywhere else. Some thirty years ago, or even less, the currently accepted architecture of the American Republic was little more than a bad repetition of the English Gothic and Classic types of revived architecture. At the present day no nation, except perhaps France, takes so keen an interest in architecture and produces so many noteworthy buildings; and it may be observed that in the States the public and the official authorities seem really to have some enthusiasm on the subject, and to desire fine buildings. But the stirring of the dry bones began in America where it ended in England. The first symptoms of an original spirit operating in American architecture showed themselves in domestic architecture, in town and country houses, the latter especially; and the form which the movement took was a desire to escape conventional architectural detail and to return to the simplest form of mere *building;* rock-faced masonry, sometimes of materials picked up on the site; chimneys which were plain shafts of masonry or brickwork; woodwork simply hewn and squared; but the whole arranged with a view to picturesque effect (Figs. 3 and 4). This form of American house became an incident in the course of modern architecture; it even had a recognizable influence on English architects. About the same time an impetus of a more special nature was given to American architecture by a man of genius, the late H. H. Richardson, who, falling back on Romanesque and Byzantine types of architecture as a somewhat unworked field, evolved from them a type of architectural treatment so distinctly his own (though its *origines* were of course quite traceable) that he came very near the credit of having personally invented a style; at all events he invented a manner, which was so largely admired and imitated that for some ten or fifteen years American architecture showed a distinct tendency to become "Richardsonesque" (Fig. 5, see Plate). As with all architectural fashions, however, people got tired of this, and the influence of another very able American architect, the late R. Morris Hunt, who had received his education at the École des Beaux-Arts of France, coupled perhaps with the proverbial philo-Gallic tendencies of the modern American, led to the American architects, during the last decade of the century, throwing themselves almost entirely into the arms, as it were, of France; seeking their education as far as possible in Paris, and adopting the theory and practice of the École des Beaux-Arts so completely that it is often impossible to distinguish their designs, and even their methods of drawing, from those of French architects brought up in the strictest régime of the "École." By this French movement the Americans have, on the one hand, shared the advantages and the influence of what is undoubtedly the most complete school of architectural training in the world; but, on the other hand, they have foregone the opportunity which might have been afforded them of developing a school or style of their own, influenced by the circumstances of their own requirements, climate, and materials. Fig. 6 (see Plate) shows an example of recent American architecture of the European classic type. Thus, in the two countries which during the last quarter of a century have shown the most activity and restlessness in their architectural aspirations, and given the most original thought to the subject, England has constantly tended towards throwing off the yoke of precedent and escaping from the limits of a scholastic style; while America, commencing her era of architectural emancipation with an attempt at first principles and simple but picturesque building, has ended by a pretty general adoption of the highly-developed scholastic system of another country. The contrast is certainly a curious one. Only one original contribution to the art has been made by America in recent days—one arising directly out of practical conditions, viz., the "high buildings" in cities; a form of architecture which may be said to be due directly to the fact that New York is built on a peninsula, and extension of the city is only possible vertically and not horizontally. The tower-like buildings, served internally by lifts, to which this condition of things has given rise (Fig. 7), form a really new contribution to architecture, and have been handled by some of the American architects in a very effective manner; though, unfortunately, the rage for rapid building in the cities of the States has led to the adoption of a system of running up such structures in the form of a steel framing, cased with a mere skin of masonry or terra cotta for appearance' sake, which in reality depends for its stability on the steel framing. This is not only a false system of architectural design, but may probably prove to be a dangerous form of building. It must be admitted, however, to be a new contribution to architecture, and renders New York, as seen from the harbour, a "towered city" in a sense not realized by the poet.

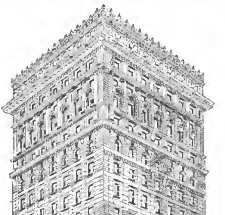


Fig. 7.—American Modern High Building (American Surety Co., New York).

Some sketch of the state of architectural thought or endeavour in England seemed essential to the subject, since it is there that what may be called the philosophy of architecture has been most debated, and that thought has had the most obvious and most direct effect on architectural style and movement. That this has been the case has no doubt been largely due to the influence of Ruskin, who, though his architectural judgment was on many points faulty and absurd in the extreme, had at any rate the effect of setting people thinking—not without result. In other countries architecture continued to pursue, up to the close of the century, the scholastic ideal impressed upon it by the Renaissance, without exciting doubt or controversy unless in a very occasional and partial manner, and without any changes save those minor ones arising from changing habits of execution and use of material. In Germany there appears to be a certain tendency to a greater freedom in the use of the materials of classic architecture, a certain relaxation of the bonds of scholasticism; but it has hardly assumed such proportions as to be ranked as a new movement in architecture.

Turning from the critical to the historical aspect of the subject, we find that in England the chief activity has been in public buildings and in street architecture. As already observed, church architecture has for the most part followed, under clerical influence, the old lines of the mediæval revival; and there have been comparatively fewer churches built than in the middle portion of the century, nor has the general interest in church architecture been of late by any means what it was during the earlier revival, the enthusiasm of which has in fact to a great extent burned itself out. There are, however, some incidents worth special notice. The building of a new cathedral is an event which stands alone in modern England. It is true that Truro Cathedral, designed by the late Mr Pearson, R.A., is not completed, but it has been carried further towards completion than was first hoped, and is perhaps the most remarkable and most successful example, in a scholastic sense, of revived Gothic, being internally almost (if one may say so) more mediæval than a mediæval cathedral itself, as far as detail is concerned, though not without original features, and externally showing the distinct impress of its architect's special feeling. One may regret that a great modern cathedral should not have been planned and designed on more modern lines; but it is a study in Gothic which speaks the thorough capacity and knowledge of its architect, and which no other country could have produced. Some of Mr Pearson's parish churches, as those of Red Lion Square and Kilburn, London, are among the best and most striking modern buildings of their type. The addition of new naves to two mediæval churches—that of Bristol, by Street, that of St Saviour's, Southwark, by Blomfield, is an interesting achievement, and in these cases the use of revived Gothic was quite justified, for reasons of architectural consistency. In opposition to such work may be mentioned the curious and characteristic incident of the delivery of St Albans Abbey (now St Albans Cathedral), one of the most interesting and most valuable of the ancient mediæval monuments of the country, into the hands of a wealthy lawyer with a taste for playing the architect, the fact of his providing the funds being apparently accepted by public opinion as a quite sufficient reason for allowing him to do what he liked with a building which is a national possession. There is probably no other civilized country in which such a proceeding would be possible. Among other events connected with the much-vexed question of restoration may be mentioned the repairing of the north transept of Westminster Abbey by Mr Pearson; in this case an excusable proceeding, as the archæological as well as architectural value of the façade had already been entirely destroyed by bad restoration earlier in the century, and Mr Pearson merely substituted good modern Gothic for bad. The taking down and rebuilding of the upper portion of the front of Peterborough Cathedral, rendered absolutely necessary on account of its structural condition, will be long remem-

British examples; churches.

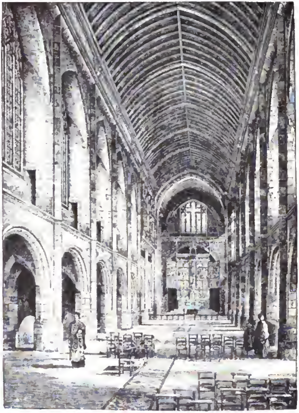


FIG. 8.—Interior, St Clare's, Liverpool. (*Leonard Stokes.*)

bered on account of the opposition raised against it by archæologists, who were unable, or did not choose, to understand the practical necessity of the case. The last years of the 19th century witnessed the progress to an

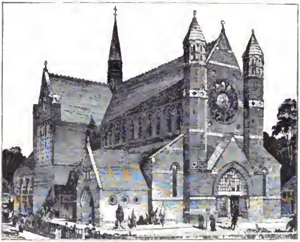


Fig. 9.—Exterior, Modern English Church. (*James Brooks.*)

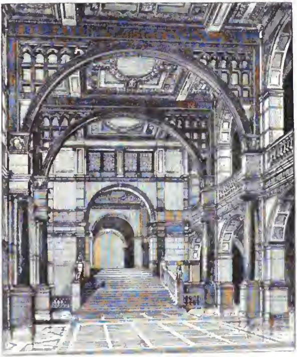


Fig. 11.—Staircase, Imperial Institute. (*Collcutt.*)

advanced stage of the most remarkable piece of English church architecture of the period, the Roman Catholic Cathedral at Westminster, by Mr Bentley; a building which is not a Gothic revival, but goes back to earlier (Byzantine) precedents; not, however, without a considerable element of novelty and originality in the design.

In ordinary church architecture, though there is still a good deal of mere imitation mediæval work carried out, we have not been without examples of a new and original application of Gothic materials. The interior of the church of St Clare, Liverpool, by Mr Leonard Stokes (Fig. 8), is a good example of the modified treatment of the three-aisled mediæval plan already referred to, the side aisles being reduced to passages; and also of the tendency in recent years to simplify the treatment of Gothic, in contrast to the florid and over-carved churches of the Gothic revival. The churches of Mr Brooks have shown many examples of a solid plain treatment of Gothic, yet with a great deal of character (Fig. 9); and the late J. D. Sedding built some showing great originality; among which the interior of his church of the Holy Redeemer, Clerkenwell, affords also an interesting example of the modern free treatment of forms derived from classic architecture.

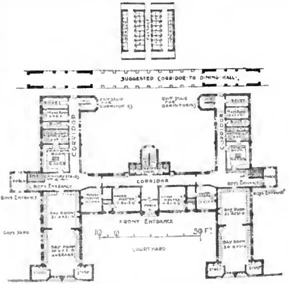


FIG. 1[illegible].—Plan of a Master's House, New Christ's Hospital. (*Webb and Bell.*)

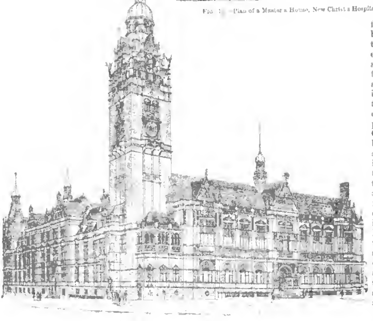


FIG. 15.—Sheffield Town Hall. (*Mountford.*)

Public buildings.

In the architecture of public buildings one of the earliest incidents in the period was the completion of the Albert Hall, which, though the work of an engineer, and commonplace in detail, is in the main a fine and novel architectural conception, and a practical success (considering its abnormal size) as a building for musical performances. Had its constructor been bold enough to roof it with a solid masonry dome, instead of a huge dish-cover of glass and iron, there would have been little to find fault with in its general conception. It was also the first modern English building of importance to be decorated externally with symbolical figure composition, in the shape of the large frieze in a coarse mosaic of terra cotta, which is carried round the upper portion of the exterior. Connected with this, both historically and in architectural grouping, is the Albert Memorial, the work of Scott, intended as a "shrine" on a great scale, which both for originality and beauty claims more credit than it has generally received. Its worst fault is that the angle piers are not adequate for the thrust of the arches, which are secured by concealed iron ties. Here again we had an early (modern) example of the sculptor working in harmony with the architect; and though there has been a great advance in English sculpture during the last quarter of the century, much of that on the Albert Memorial still commands admiration; the colossal central figure, entirely out of scale with the rest, being unfortunately the weakest portion of the work. The subject of the Government Offices in London forms in itself an important chapter in recent architectural history. The Home and Foreign Office block was finished in 1874: a sumptuous, but weak and ill-planned building designed by Scott, *invitâ Minervâ*, in a style alien to his own predilections. In 1884 took place the great competition for the War and Admiralty Offices conjointly, won by a commonplace but admirably drawn design, presenting some good points in planning. The building was to stand between Whitehall and St James's Park, with a front both ways. The competition came to nothing, and the successful architects were eventually employed to build the new Admiralty as it now stands, a mean and commonplace building with no street frontage, in which economy was the main consideration, and totally discreditable to the greatest naval power in the world. In 1898-99 it was at last resolved to build a War Office and other Government Offices much needed, and an irregular site opposite the Horse Guards was selected for the War Office and one in Great George Street for the others. In this case there was no competition, but the Government selected two architects after inquiry as to their works ("classic" architecture being a *sine quâ non*); Mr Young for the War Office, and Mr Brydon for the Great George Street block. The War Office site is inadequate and totally unsymmetrical, the boundary of the building being settled by the boundary of the street curb, and the inner courtyards will be of very mean proportions compared with the great courtyard of the Home and Foreign Office. Both architects have produced grandiose designs, but in regard to the War Office at least the Government have thrown away a great opportunity. Unfortunately, throwing away great opportunities has been the history of the Government buildings ever since the Houses of Parliament, a really fine building, was completed.

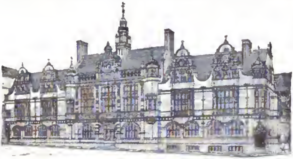


Fig. 16.—Oxford Town Hall. (*Hare.*)

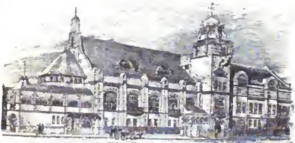


Fig. 17.—Northampton Institute. (*Mountford.*)

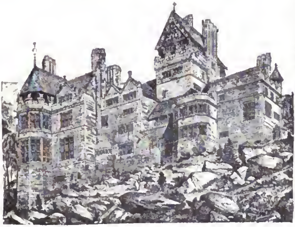


Fig. 18.—Cragside. (*R. Norman Shaw, R.A.*)

There can only be further enumerated a few of the more important buildings carried out in England during the later years of the 19th century, and mention made of the general course which architecture has taken in regard to special classes of buildings. The Natural History Museum (Fig. 10, see Plate), completed in 1881 by Mr Alfred Waterhouse, may stand as a type of the taste for the employment of terra cotta, with all its dangerous facilities in ornamental detail, which that architect specially set the example of. Detail is certainly overdone here, but the building is strikingly original; a point not to be overlooked in these days of architectural copying. The Imperial Institute, the result of a competition among six selected architects, represents also a type of architecture which its architect, Mr Collcutt, may be said to have matured for himself, and which has been extensively imitated; a refined variety of free classic, always quiet and delicate in detail, though perhaps rather wanting in architectonic force (Fig. 11). The next great architectural competition was that for the completion of the South Kensington Museum, the bare brick exterior of which, waiting for architectural completion, had long been a national disgrace. The competition produced some fine and striking designs, some of them perhaps more so than the selected one by Mr Aston Webb, whose fine plan, however, justified the selection. Another competition which excited general interest was that in 1894, for the rebuilding on a country site of Christ's Hospital Schools, also gained by Mr Webb (in collaboration with Mr Ingress Bell), by a design which, in its arrangement of schoolhouses in detached blocks (Fig. 12), but in a symmetrical grouping, opened up a new idea in public school planning, and struck a blow at the picturesque but insanitary quadrangle system. Among notable public buildings of the period ought to be mentioned Mr Norman Shaw's New Scotland Yard, built in a style neither classic nor Gothic, but partaking of the elements of both (Figs. 13 and 14, see Plate); a work which has perhaps been a little over-praised, just as it has been very superficially condemned, but which is a remarkable example of novel and picturesque design, though most of the details, taken separately, are imitative.

In recent years there has been a great movement or building town halls; towns rather vying with each other in this way. Of late nearly all of these have been carried out in some variety of free classic. Among the more important in point of scale is that of Sheffield, by Mr Mountford (Fig. 15); among smaller ones, those of Oxford, by Mr Hare (Fig. 16), and Colchester, by Mr Belcher, are particularly good examples of recent architecture of this class, the former distinguished also by an exceptionally good plan. The merit of excellent planning also belongs to Messrs Aston Webb and Ingress Bell's Birmingham Law Courts, one of the modern terra-cotta buildings of somewhat too florid detail, though picturesque as a whole. Among public halls the M'Ewan Hall at Edinburgh, completed in 1898 from the designs of Dr Rowand Anderson, deserves mention as one of the most original and most carefully designed of recent buildings in Great Britain.

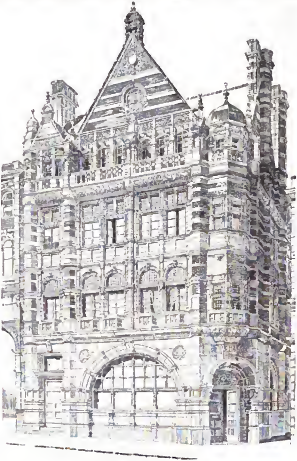


Fig. 19.—City Bank, Ludgate Hill. (*Collcutt.*)

The various new buildings erected in connexion with the University of Oxford, those by Mr T. G. Jackson especially, form an important incident in modern English architecture. Mr Jackson has succeeded to a remarkable degree in designing new buildings which are in harmony with the old architecture of the university city; sometimes perhaps a little too imitative of it, but at any rate he has the credit of having added rather extensively to Oxford without spoiling it; while his school buildings in different parts of the country have a refinement and domesticity of feeling which is the true note of school

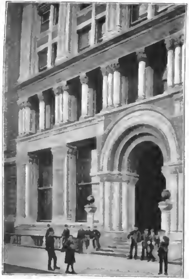


Fig. 5.—"Richardsonesque" Style—U.S. Trust Co., New York.

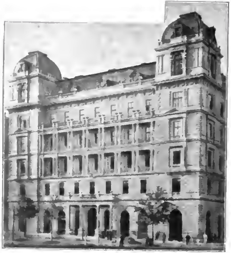


Fig. 25.—Type of Vienna Architecture—Police Headquarters.

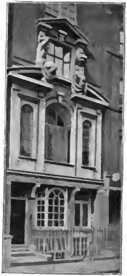


Fig. 21.—House, Margaret Street, London. (*Beresford Pite.*)

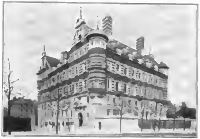


Fig. 13.—New Scotland Yard, showing lower storeys. (*Norman Shaw.*)

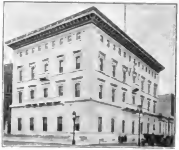


Fig. 6.—American Modern Classic—Metropolitan Club, New York.

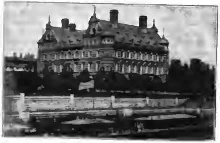


Fig. 14.—New Scotland Yard, showing roof. (*Norman Shaw.*)

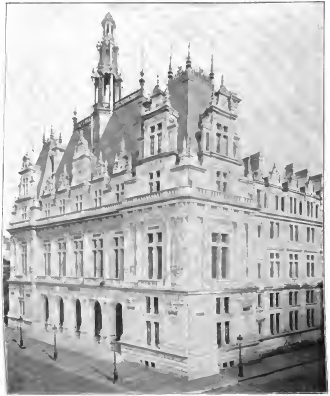


FIG. 24.—Mairie, Tenth Arrondissement, Paris. (*Rouyer.*)

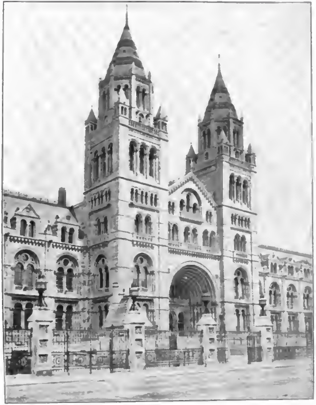


FIG. 10.—Natural History Museum, Kensington. (*Waterhouse.*)

architecture. Among buildings of an educational class, the move in technical education has led to the erection of

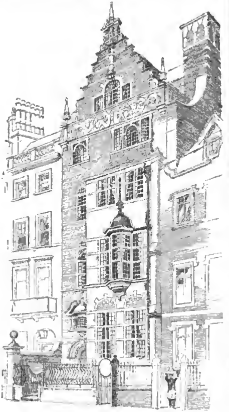


FIG. 20.—House, Buckingham Gate. (*R. Blomfield.*)

a good many large polytechnic and similar institutions, which in many cases have been well treated architecturally; the Northampton Institute at Clerkenwell (Fig. 17), by Mr Mountford, being perhaps one of the boldest and most effective of recent public buildings. In the building of hospitals and asylums much has been done, and great progress made in the direction of hygienic and practical planning and construction, but the tendency has been (perhaps rightly) towards making this practical efficiency the main consideration, and reducing architectural treatment to the simplest character. The well-known St Thomas's Hospital, at Lambeth, exemplifies the treatment of hospital architecture at the commencement of our period; the separate pavilion system had been already adopted on practical grounds, but the building is treated in a sumptuous architectural style, as if representing so many detached mansions; a treatment which would now be deprecated as an expenditure foreign to the main purpose of the building. One recent hospital, however, that at Birmingham, by Mr Henman, combines architectural effect with the latest hygienic improvements, and is the first large hospital in Great Britain in which the system of mechanical ventilation has been completely and consistently carried out.

In theatre building there has been an immense improvement in regard to planning, ventilation, and fire-proof construction, but little to note in an architectural sense, since theatres in England are never designed by eminent architects, the financial and practical aspects being alone considered.

In domestic architecture the tendency has been to quit picturesque irregularity for a more formal and more dignified treatment. Such a house as Mr Norman Shaw's "Cragside," built in the earlier part of our period (Fig. 18), however its picturesque treatment may still be admired, would hardly be built now on a large scale; its architect himself has of late years shown a preference for a symmetrical and regular treatment of house architecture, sometimes to the extent of making the mansion look too like a barrack. In street architecture, however, the tendency has been towards a more characteristic and more picturesque treatment; nor is there any class of building in which the improvement in English architecture during the last quarter of a century has been more marked and more unquestionable. Many of the new residential streets in the west end of London present a really picturesque *ensemble*, and many shops and other commercial street buildings have been erected with admirable fronts from the designs of some of the best architects of the day. Mr Norman Shaw's building at the corner of St James's Street and Pall Mall was one of the first, and is still one of the best examples of modern street architecture. As later examples may be cited Mr Collcutt's City Bank in Ludgate Hill (Fig. 19), and Mr R. Blomfield's narrow house-front in Buckingham Gate (Fig. 20). The introduction of sculpture in street fronts is also beginning to receive attention; and a simple house-front recently erected in a London street, from the design of Mr Beresford Pite (Fig. 21, see Plate), is an excellent example of the use of sculpture in connexion with ordinary street architecture. It is significant of the increased attention accorded to street architecture, that the most important architectural event in England at the very close of the 19th century, was the outlay of £2000 by the London County Council, in fees to eight architects for designs for the front of a proposed new street.

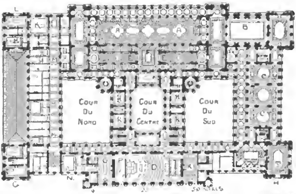


FIG. 22.—Plan of Hôtel de Ville, Paris. A, Salle des Fêtes; B, Salle à manger; C, Salons de Reception; D, Council Chamber; E, Grand Staircase; F, Salle des Cariatides; G, General Secretary; H, Prefect; K, Committee Rooms; L, Public Works; M, Corridor; N, President of Council; O, Library; P, Refreshment Room.

Turning to the Continent, we find in France, still the leading artistic nation of the world, that the art of architecture has been in a most flourishing and most active state during the last quarter of a century. It is true that there is not the same variety as in modern English architecture, nor have there been the same discussions and experiments in regard to the true aim and course of architecture which have excited so much interest in England; because the French architects, unlike the English, know exactly what they want. They have a "school" of architecture; they adhere to the scholastic or academic theory of architecture as an art founded on the study of classic models; and on this basis their architects receive the most thorough training of any in the world. This predominance of the academic theory deprives their architecture, no doubt, of a good deal of the element of variety and picturesqueness; a French architect *pur sang*, in fact, never attempts the picturesque, unless in a country residence, and then the results are such that one wishes the attempt had not been made. But, on the other hand, modern French architecture at its best has a dignity and a style about it which no other nation at present reaches, and which goes far to atone for a certain degree of sameness and repetition in its motives; and living under a Government which recognizes the importance of national architecture, and is willing to spend public money liberally on it (with the full approbation of its public), the French architects have opportunities which English ones but seldom enjoy—the predominant aim with a British Government being to see how little they can spend on a public building. The two great Paris exhibitions of 1889 and 1900 may be regarded as important events in connexion with architecture, for even the temporary buildings erected for them showed an amount of architectural interest and originality which could be met with nowhere else, and which in each case left its mark behind it, though with a difference; for while in the 1889 exhibition the main object was to treat temporary structures—iron and concrete and terra cotta—in an undisguised but artistic manner, in those of the 1900 exhibition the effort was to create an architectural *coup d'œil* of apparently monumental structures of which the actual construction was disguised. In spite of some eccentricities, the amount of invention and originality shown in these temporary buildings was most remarkable; but fortunately the exhibition left something more permanent behind it in the shape of the two Art-palaces and the new bridge over the Seine. The two palaces are triumphs of modern classic architecture; the larger one (by MM. Thomas, Louvet, and Deglane) is to some extent spoiled by the apparently unavoidable glass roof; the smaller one, by M. Girault, escapes this drawback, and, still more refined than its greater opposite, is one of the most beautiful buildings of modern times; while the

France.

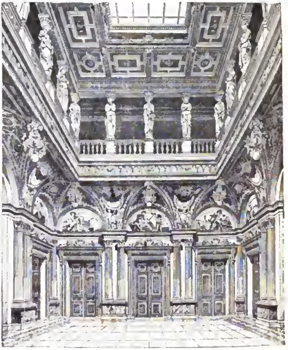


Fig. 24.—Salle des Cariatides, Hôtel de Ville, Paris.

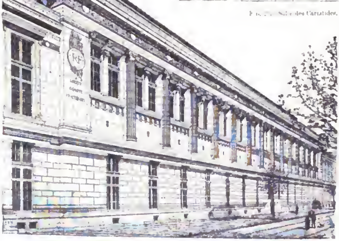


Fig. 25.—École de Medecine, Paris. (*Ginain.*)

architectural pylons, with their accompanying sculpture, which flank the entries to the bridge, are worthy of the best period of French Renaissance. Thus much, at least, has the 1900 exhibition done for architecture.

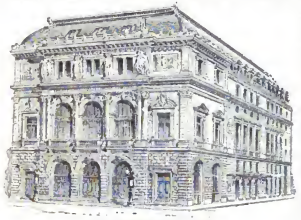


Fig. 26.—Opéra Comique, Paris. (*Bernier.*)

At the beginning of our period stands one of the most important of modern French buildings, the Paris Hôtel de Ville, commenced shortly after the war, from the designs of MM. Ballu and Deperthes, planned on an immense scale, and on the stateliest and most monumental lines (Figs. 22, 23). The central block is, externally, a restoration of the old Hôtel de Ville, the remainder carried out in an analogous but somewhat more modern style. The interior has been the scene of sumptuous pictorial decoration, in which all the first artists of the day were employed—unfortunately in too scattered a manner, and on no predominant or consistent scheme. During the period one of the most characteristic architectural efforts of the French has consisted in the erection of the various smaller Hôtels-de-ville or Mairies, in the city and suburban districts of the capital; as at Pantin, Lilas, Suresnes, and in various arrondissements within the city proper (Fig. 24, see Plate). Nothing shows the quality of modern French architecture better, or perhaps more favourably, than this series of district town halls; all have a distinctly municipal character and a certain family resemblance of style amid their diversity of details; all are refined specimens of pre-eminently civilized architecture. Among the greater architectural efforts of France during the last decade or two are the immense block of the new Sorbonne, by M. Nénot, a building sufficient in itself for an architectural reputation; and the great church of the Sacré Cœur, overlooking Paris from the hill of Montmartre, an erection of such monumental massiveness as we never see in modern England, which was in progress for many years, from the designs of the late M. Abadie, and in the year 1900 was still unfinished. In church architecture generally France has not shone very much during the latter part of the century; all her finest modern classic churches date from before the war. Among smaller French buildings of peculiar merit may be mentioned the Musée Galliera, in the Trocadéro quarter of Paris, designed by M. Ginain—a work of pure art in architecture such as we should nowadays look for in vain out of France; the École de Médecine, by the same refined architect (Fig. 25); and the chapel in Rue Jean Goujon (Guilbert), erected as a memorial to the victims of the bazaar fire, again a notable instance of a work of pure thought in architecture—a new conception out of old materials. The new Opéra Comique (Bernier) should also be mentioned (Fig. 26), the rather disappointing result of a competition which excited great interest at the time. Street architecture has been carried out of late in Paris in a sumptuous style (Fig. 27), with great stone fronts and a profusion of carved ornament, such as we know nothing of in England; and though there is a rather monotonous repetition of the same style and character

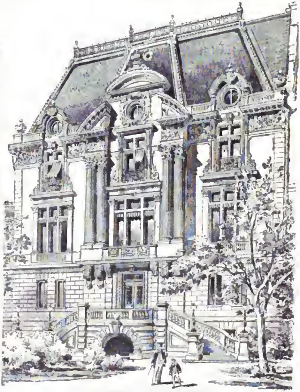


Fig. 27.—Example of Paris Street Architecture.

throughout the new or newly-built streets, it is impossible to deny the effect of palatial dignity they impart to the city. In the matter of country houses the French architect is less fortunate; when he attempts what he regards as the rural picturesque, his good taste seems entirely to desert him, and the *maison de campagne* (Fig. 28) is generally a mere riot of gimcrack.

Germany.

The great military success of Germany in 1870, and the founding of the German empire, gave, as is usual in such crises, a decided impetus to public architecture, of which the central and most important visible sign is the German Houses of Parliament, by Professor Wallot, whose design was selected in a competition. There is something essentially German in the quality of this national building; classic architecture minus its refinement. The detail is coarse; the finish of the end pavilions of the principal front absolutely unmeaning—mere architectural rodomontade; the central cupola of glass and iron, on a square plan, probably the ugliest central feature on any great building in Europe; and yet there is undeniable power about the whole thing; it is the characteristic product of a conquering nation not reticent in its triumph. The interior of the vestibule is shown in Fig. 29. The new cathedral at Berlin, by Professor Raschdorff, is the other most important German work of the period (Fig. 30); a building very striking and unusual in plan, but absolutely commonplace in its architectural detail; school classic of the most ordinary type, without even any of those elements of originality which are to be found in the Houses of Parliament. A curious feature in the plan (Fig. 31) is that the building, alone of any cathedral we can recall, has its principal general entrance at the side, the end entrance being reserved for a special imperial cortège on special occasions, the cathedral also serving the second purpose of an imperial mausoleum. Theatre building has been carried on very largely in Germany, and among its productions the Lessing Theatre at Berlin (Fig. 32) (von der Hude and Hennicke) is a favourable example of German classic at its best, besides being, like most modern German

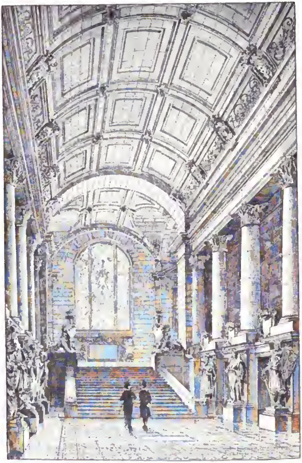


Fig. 29. Interior, Houses of Parliament, Berlin. (*Wallot.*)

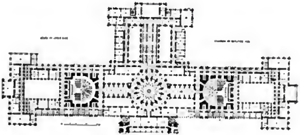


FIG. 37.—Plan of Parliament Houses, Budapest.

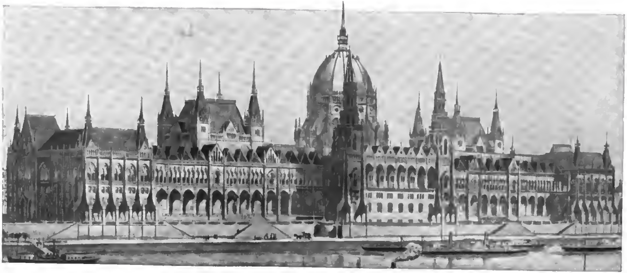


FIG. 36.—Houses of Parliament, Budapest. (*Steindl.*)

theatres, very well planned (Fig. 33). Hamburg has had its new municipal buildings (Herr Grotjan), a florid Renaissance building with a central tower, showing in its general effect and grouping a good deal of Gothic feeling. Mention may also be made of the new Law Courts at Leipzig (Herr Hoffmann), a building with no more charm about it, externally, than the Berlin Parliament Houses, but with some good interior effects (Fig. 34). The new Post Offices in Germany have been an important undertaking, and are, at all events, buildings of more mark than those in England. There has also been a great deal of new development in street architecture, which shows an immense variety, and a constantly evident determination to do something striking; but we find in it neither the dignity of Parisian street architecture nor the refinement of modern London work; there is an element of the bombastic about it.

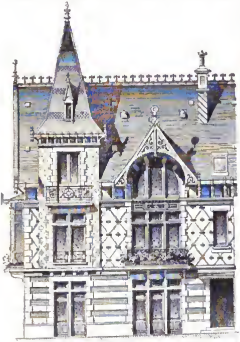


Fig. 28.—French "Maison de Campagne" (mild type.)

Other countries.

No modern building on the European continent is more remarkable than the Brussels Law Courts, built in the early years of our period, from the designs of the late M. Poelaert, an original genius in architecture, who had the good fortune to be appreciated and given a free hand by his Government. The design is based on classic architecture, but with a treatment so completely individual as to remove it almost entirely from the category of imitative or revival architecture; somewhat fantastic it may be, but as an original architectural creation it stands almost alone among modern public buildings. In Vienna the scholastic classic style has been retained with much more purity and refinement than in the German capital (Fig. 35, see Plate). Budapest, on the other hand, which has almost sprung into existence since 1875 as the rival of the Austrian capital, has erected a great Parliament building of florid character (Fig. 36, see Plate), in a style in which the Gothic element is prevalent, though the central feature is a dome. The plan (Fig. 37, see Plate) is obviously based on that of the Westminster building; the exterior design, however, has the merit of clearly indicating the position of the two Chambers as part of the architectural design, the want of which is the one serious defect of Barry's noble structure. In Italy modern architecture is at a very low ebb; the one great work which comes within our period has been the building of the façade to the Duomo at Florence, from the design of the late De Fabris, who did not live to see its completion. As the completion in modern times of a building of world-wide fame, it is a work of considerable interest, and, on the whole, not unworthy of its position; that it should harmonize quite satisfactorily with the ancient structure was hardly to be expected. It was probably the completion of this façade which led the city of Milan to start a great architectural competition, a few years since, for the erection of a new façade to its celebrated cathedral, not because the façade had never been completed, but because it had been spoiled and patched with bad 18th-century work. The ambition was a legitimate one, and the competition, open to all the world, excited the greatest interest; but the young Italian architect, Brentano, to whom the first premium was awarded, died shortly afterwards, and other causes, partly financial, led to the postponement of the scheme, though it is understood that there is still an intention of carrying out Brentano's design under the direction of the official architectural department of the city.

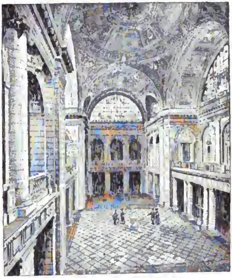


Fig. 34.—Interior of Leipzig Law Courts. (*Hoffmann.*)

Authorities.—The literature of architecture as a modern art is limited, the most important publications of recent times being mainly devoted to the study and illustration of ancient architecture. The following, however, may be named:—James Fergusson. *History of Modern Architecture* (2nd edition). London, John Murray, 1873.—T. G. Jackson. *Modern Gothic Architecture.* London, H. S. King, 1873.—J. T. Micklethwaite. *Modern Parish Churches.* London, 1874.—E. R. Robson. *School Architecture.* London, John Murray, 1874.—J. J. Stevenson. *House*

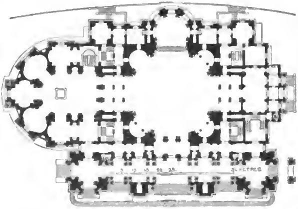


FIG. 31.—Plan of Berlin Cathedral.

Architecture. London, Macmillan, 1880.—E. E. VIOLLET-LE-DUC. *How to build a House* (translated from the French). London, 1874.—*Lectures on Architecture* (translated). London, 1881.—H. C. BURDETT. *Hospitals and Asylums of the World.* London, Churchill, 1892-93.—Professor OSWALD KUHN. *Krankenhauser.* Stuttgart, 1897.—E. O. SACHS. *Modern Opera-Houses and Theatres.* London, Batsford, 1897-99.—E. WYNDHAM TARN. *The Mechanics of Architecture.* London, Crosby Lockwood and Son, 1893.—R. NORMAN SHAW, R.A., T. G. JACKSON, R.A. (and others). *Architecture, a Profession or an Art* (a collection of essays). London, John Murray, 1892.—W. H. WHITE. *The Architect and his Artists.* London, 1892.—*Architecture and Public Buildings in Paris and London.* London, King and Son, 1884.—H. H. STATHAM. *Architecture for General Readers.* London, Chapman and Hall, 1895.—*Modern Architecture.* London, Chapman and Hall, 1898.—HERRMANN MUTHESIUS. *Die Englische Baukunst der Gegenwart.* Berlin and Leipzig, 1900.—DER ARCHITEKTEN VEREIN ZU BERLIN. *Berlin und Seine Bauten.* Berlin, Ernst und Sohn, 1896.

The real literature of modern architecture, however, is to be found mainly in the articles and illustrations in the best periodical architectural publications of various countries. Among these Italy has none worth mention, and France, with all her architectural enthusiasm, has had no first-class architectural periodical since the extinction, about 1890, of the *Revue générale de l'Architecture,* conducted for more than fifty years by the late César Daly, and in its day the first periodical of its class in the world. The following are the best publications at present:—*The Architectural Record* (quarterly). New York.—*The Architectural Review* (monthly). Boston, U.S.A.—*The Allgemeine Bauzeitung* (quarterly). Vienna.—*The Berlin Architekturwelt* (monthly). Berlin.—*The Builder* (weekly). London.—*La Construction Moderne* (weekly). Paris.

(H. H. S.)

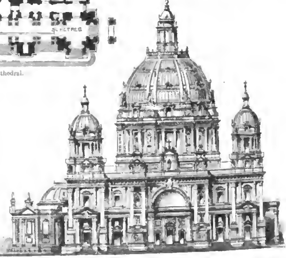


FIG. 30.—Berlin Cathedral. (*Raschdorff.*)

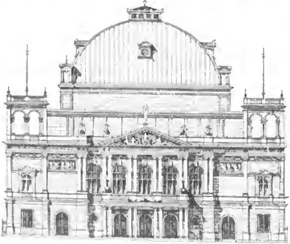


FIG. 32.—Lessing Theatre, Berlin. (*Von der Hude and Hennicke.*)

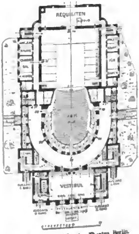


FIG. 33.—Plan of Lessing Theatre, Berlin.

II. Recent Archæological Discoveries.

Archæological research since 1875 has not only enriched the museums of Europe with priceless treasures, but, by the adoption of a much more scientific system of excavation, has been able to complete and rectify the discoveries of earlier explorers, and to fill up the gaps in the history of the origin and development of the earlier architectural styles. In two of these—viz., the Egyptian and the Greek—the researches of Professor Flinders Petrie in Egypt, and of Dr Schliemann, Dr Dörpfeld, and Mr Homolle in Greece, have placed the archæological history of architecture on a surer and better-defined basis than heretofore.

Egyptian.

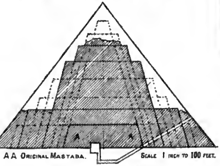


Fig. 1.—Pyramid of Medum (Meidoun).

Taking the earliest structures first, we learn from Professor Flinders Petrie's work on *The Pyramids and Temples of Gizeh*, that the oldest pyramids known are those of Sakkara and Medum (Meidoun), and these were not only of different construction from any of the others, but when the latter was completed it reached the form afterwards adopted in the true pyramids. The kernel of the Sakkara and Medum pyramids belong to the class known as mastaba tombs. The term mastaba (Arabic for "bench") has been given to the sloping-sided tombs, of about 76° angle and from 10 to 20 feet in height (Fig. 1). In their origin they are probably copies in stone of the crude brick dwellings of the Egyptians, the walls of which must be much thicker at the bottom than at the top, to carry the superincumbent weight. Both the pyramids above named are known as cumulative or superposed mastabas[1]—*i.e.*, successive enlargements have been made to them, having been after each completion again enlarged by another coat of rough masonry with another fine polished casing outside. The pyramid of Sakkara was never completed, and has retained the stepped form which these successive casings gave to it. In the Medum pyramid the tower-like appearance, at present, of the centre portion is due to two of the lower enlargements having fallen away (Fig. 2). Before the final casing the successive enlargements had resulted in seven steps, the outer angles of which were pyramidal; the last process was to add a smooth casing to one slope from base to top. The angle thus formed was about 52°. These two pyramids are the only ones built in this way; in all the others the full size was settled from the first, though a change from the original size seems to have been made during its construction, in the third pyramid of Menkaura.

From Professor Flinders Petrie's measurements of the Great Pyramids, the original dimensions have now been ascertained exactly. The external dimensions of the first pyramid, that of Khufu, are 755 ft. 8 in. as the mean of the four sides, with an extreme difference of 1·7 of an inch. The height from the level of the artificial pavement round the pyramid to the apex was 481 ft. 4 in., and the angle of casing, 51·52°. In the second pyramid, Khafra, the lowest course was in granite, and had a vertical base 11 in. high, against which the artificial pavement was laid. The side dimensions were 706 ft. 3 in. as a mean, with an extreme difference of 5 in. The height was 472 ft., and the angle of casing 53·10°. The third pyramid, Menkaura, was never quite completed, the mean length of the sides was 346 ft., the height 215 ft. and the angle 51·10°. The lower portion of this pyramid was cased with granite to about one-fourth up, and the rough surface of the granite casing was never worked off. Part of the outer casing still remains on the second pyramid. The casing stones were not simply triangular blocks filling up the angles formed by the receding steps, but from 7 to 10 feet in depth, so that their bedding must have begun at the bottom.

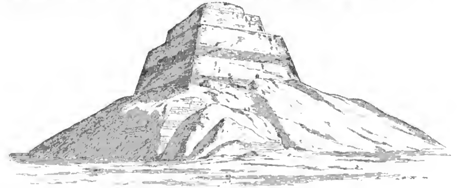


Fig. 2.—Pyramid of Medum.

In the course of his researches at Gizeh in 1881-82, Professor Flinders Petrie made a minute examination of the granite blocks inside the Great Pyramid, and of the debris in granite chips and diorite on the site of the workshops of the masons who built the Pyramids, and ascertained that the typical method of working hard stones, such as granite, basalt, and diorite, was by means of bronze tools set with cutting points, probably of corundum, as the diamond is not known in Egypt, and that the masons employed straight and circular saws and tubular drills.

---

[1] It still retains a portion of its original casing at the top (see Fig. 2).

The pyramid of Medum, already mentioned, was built by Sneferu, the first king of the fourth dynasty, c. 3998-3969 B.C.; and on the east side Professor Petrie discovered a small temple attached to it, consisting of two chambers roofed over in stone with two steles and an altar between on the roof. Traces of other temples have since been found on the east side of the Great Pyramids; and from the temple of the second pyramid a causeway led down to the granite temple, known as the temple of the Sphinx (Fig. 3), the earliest temple known, and, according to Professor Petrie, built by Khafra after the completion of his pyramid. The temple, though now buried, was originally a free-standing building on the plain at the foot of the hill. The tablet referring to the restoration of the Sphinx by Khufu is now recognized as a forgery of the twentieth dynasty. No mention is made of the Sphinx on any monument of the old kingdom, and Professor Petrie places its date between the sixth and the tenth dynasties.

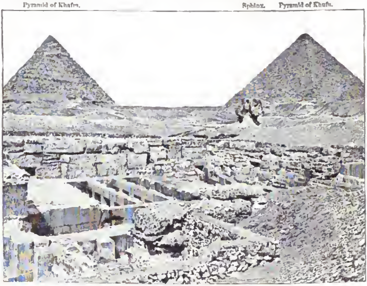


Fig. 3.—Temple of the Sphinx.

Of the famous Labyrinth built by Amenemhat III., c. 2622-2578 B.C., nothing remains but the site, about 1000 × 800 feet—the masses of buildings described by Lepsius are, according to Professor Petrie, the brick houses of a Roman village built on the site. The Hawara pyramid on the north side was erected by the same king. It was built in crude brick and coated with a fine limestone casing like the other pyramids; its dimensions are about 334 feet wide and 197 feet high. In the interior of this pyramid Professor Petrie discovered a pointed arch 3 feet in depth and composed of three rings of bricks, which was employed to take off the weight of the upper part of the pyramid from the roof of the tomb chamber. The Pyramid of Illahun, built by Usertasen II., c. 2684-2660 B.C., to the south-east of, and situated about a mile from the Labyrinth, was partly composed of solid rock about 40 feet high, isolated by the cutting away of the rock round it. The upper portion consisted of cross walls of stone, fitted in with crude brick and cased afterwards with limestone. It was near this pyramid that Professor Petrie discovered the town of Kahun, erected to house the overseers and workmen who built the pyramid, and deserted by them on its completion. The walls were all of crude brick, and where the rooms exceeded 8 or 9 feet in width columns of wood or stone were employed to assist in carrying the roof. The lower portion of a column fluted like those at Benihassan was found on its stone base.

The pyramidal form given to the stone pylons of Egyptian temples is now generally acknowledged to have been derived from the material in which the earlier examples were built, viz., crude brick, the raking sides arising from the fact that these crude brick walls are always, for reasons already given, much thicker at the bottom. Even at the present day the pigeon-houses built on the roof of the modern Egyptian dwelling-houses take the same shape, and in the distance are often mistaken for temples.

During 1894 and following years excavations have been carried out under the direction of Mr Naville at Deir-el-Bahri, the splendid temple built by Queen Hat'shepsut 1516-1503 B.C., and by the removal of the superincumbent earth a great portion of the temple foundations have been exposed. In that part buried by the falling in of the rock above at the north-east end, the hypostyle hall and colonnade are almost perfect. Since the plan was measured by Professor Brune in 1866 and published by Mariette, with some incorrect alterations, the principal architectural discovery has been that of the great altar in the north-east court, the only complete example found in Egypt, its preservation being due to the falling in of the rock above. Professor Brune's restorations made in 1866-67, and published by Mariette, give an excellent idea of the aspect of this remarkable temple, which was built on a series of terraces; except that the later discoveries have shown the north-east corner to have been different in plan from the north-west corner.

In 1891-92 Professor Petrie excavated and uncovered the remains of the Palace of Khu-en-aten (Amen-hotep IV.) 1383-1365 B.C., who not only made changes in the religious worship of the country, but in the decoration of his palace departed from the conventional art of the period, and introduced a reform therein. In the pavement and frescoes of the walls the subjects are selected from out-of-door life, and birds, insects, and water-plants are depicted with marvellous fidelity to nature. The temple of Luxor has also been cleared out under Mr Maspero, so that those portions of the plan which were covered over and hidden by modern buildings are now exposed.

Persian.

Mr Marcel Dieulafoy's excavations at Susa in 1884-86 have confirmed those made by Sir Kenneth Loftus in 1850 as regards the three great porticoes and the Apadana, or Hall of Columns of the Palace of Artaxerxes Mnemon. The walls enclosing the hall and flanking the porticoes, as conjectured by Fergusson, no longer existed, being probably built in unburnt brick; but the discovery of fragments of the pavement inside the hall and in the rear of the north and west porticoes, which stopped on the lines where the walls (16 feet thick) should have been found, is a sufficiently clear proof of their existence. The fourth or south side of the Apadana opened on to a court, and facing the hall, on the right and left of the court, were two walls, which were decorated with the famous frieze of archers now in the Louvre. The wall had apparently fallen down on its face, and thus preserved more or less intact this frieze, which was executed in enamel in bright colours on beton blocks. Farther to the south Mr Dieulafoy found the grand staircase leading to the palace similar to the well-known example at Persepolis, except that the walls were here decorated with enamelled beton blocks. At Persepolis in 1891 Mr Weld Blundell ascertained, firstly, that the drain which was supposed to run under the site of what in Fergusson's restoration should be a wall was carried between the wall and the first row of columns; secondly, that two of the vertical stone rain-water pipes rose above the pavement of the terrace, proving that they were brought down inside the wall from the roof above the Hall of Columns; and, thirdly, that the three porticoes were flanked by towers, the foundations of which were traced below the hard lime crust which had been mistaken for the solid rock, thus confirming Fergusson's restoration.

Greek.

Although the excavations made by Dr Schliemann in Troy, Mycenæ, and Tiryns have in the main an archæological rather than an architectural value, the discovery of the plan of the Palace of Tiryns has enabled Dr Dorpfeld to trace the origin of many of the characteristic features of Greek architecture. The propylæa or entrance gateways were of the same plan as that subsequently developed into the Hexastyle porticoes of the Propylæa at Athens and other sacred enclosures. In the megaron or men's hall of the palace, with its Portico-in-antis and vestibule, Dr Dorpfeld recognizes the model of the cella of the Greek Doric Temple. The researches revealed that the primitive construction consisted of a foundation wall about 3 feet in height, built in rubble masonry laid in clay mortar, and of such thickness as to suggest that the upper part of the walls was built in crude or unburnt brick. In order to protect the face of the antæ of the Portico-in-antis, and in conjunction with the two columns of the portico, to carry the architrave, vertical posts or planks of wood were employed, secured by wooden dowels to a stone base. The two columns of the Portico-in-antis were in timber, their trace being shown on the stone bases still *in situ*, which were raised two inches above the pavement, a precaution taken to protect the base of a wooden column. This timber construction was afterwards copied in stone, and is the origin, according to Dr Dorpfeld, of the slightly projecting antæ employed afterwards decoratively in all Greek temples. Further evidence of the correctness of this theory has been found in the temple of Hera at Olympia, which was excavated by the German Government in 1875-85. Here the lower part of the walls was in masonry of small dimensions carrying a superstructure in crude brick, and the antæ were protected and strengthened by vertical posts of timber, traces of which were found on the stylobate or upper step. Here also, as in Tiryns, the doorposts of the entrance doorway were in timber. In the Heraion, however, that which at Tiryns constituted the megaron had become the cella of the temple, and a further development had taken place by the surrounding of the same with a peristyle of columns to protect the external wall of the cella, and probably its stucco face and painted decoration. The variety of profile shown in the stone capitals found on the site, and the fact that Pausanias mentions his having seen a wooden column in the opisthodomus, have led to the conclusion that originally all the columns of this temple were in wood, being replaced gradually by copies in stone. Their wide intercolumniation proves also that the entablature was in wood, and the discovery of some of the terra-cotta tiles and antefixæ shows that the wooden roof was covered with tiles. The probable date of the foundation of the temple is placed by Dr Dorpfeld in the 11th cent. B.C.; four centuries, therefore, before the earliest stone temples known, viz., those of Apollo and of Zeus at Syracuse.

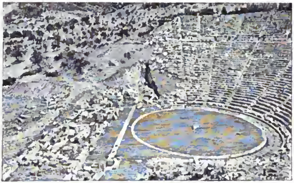


FIG. 4.—The Theatre of Epidaurus.

The excavations at Olympia have laid bare the whole site of the Altis or sacred enclosure, and some of the structures of later date round the same. It may be pointed out that the preservation and recovery of the famous statue of Hermes by Praxiteles is due to its having been thrown down by, and buried in, the clay of the crude brick walls of the cella; when that happened no one knows, but it is strange that so ephemeral a material as unburnt brick should, if our dates are correct, have been preserved for thirteen or fourteen centuries. The researches of Blouet and other explorers in the earlier part of the 19th century had made known to us the plan of the Temple of Zeus, which was Hexastyle Doric with thirteen columns in the flanks, and of the usual type, with pronaos, epinaos, and cella. The entire clearance of all the superincumbent earth has, however, revealed many other features in the plan which bear out Pausanias' description. First, within the entrance to the cella were staircases leading to the galleries, "through which there is an approach to the image." On the pavement were seen the traces of the barrier across the cella between the second column on each side and of other barriers restricting the passage to the side aisles. In front of the pedestal which carried the famous chryselephantine statue of Zeus, by Phidias, were found the traces of the black stone paving with the raised margin of Parian marble to hold the oil which, according to Pausanias, was kept there to preserve the ivory, a precaution rendered necessary by the dampness of the Altis. The position of this sunk space filled with oil quite disposes of the hypæthron, and there is no doubt that in this temple the statue was lighted only through the open door.

In the Byzantine church, outside the Altis, have been recognized the lower parts of the walls of the workshop of Phidias, mentioned by Pausanias. It was of the same size as the cella of the temple.

In order to carry out systematically the explorations at Delphi, begun in 1891 by the French School at Athens, it was found necessary to expropriate the inhabitants of Kastri, a small village built on the sacred enclosure, providing accommodation for them elsewhere. This, combined with the labour involved in clearing away the superincumbent earth and the debris of the village, and conveying it some distance, necessarily delayed the work. Here, as at Olympia, the writings of Pausanias have been of the greatest value in the nomenclature of the various buildings and monuments the foundations of which were found on either side of the sacred way. This, owing to the steepness of the hill, winds round at a gentle slope from the entrance of the sacred enclosure at the south-east, rising across the same to the west and returning to the foot of the steep ascent leading to the raised terrace on which the Temple of Apollo was built. The excavations have exposed the whole of the peribolos or wall surrounding the temenos or sacred enclosure, the foundations of all the treasuries and votive monuments, and the terrace wall; the latter, carrying the platform of the temple, is one of the finest examples known of polygonal masonry. Comparatively little was found of the architectural features of the Temple of Apollo, but those of the several Treasuries are of importance in one case, that of the Siphnians allowing of a more or less complete conjectural restoration.

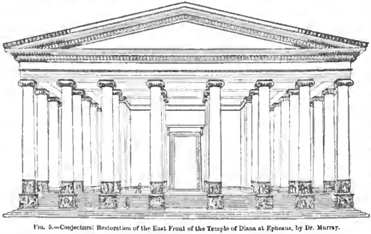


FIG. 5.—Conjectural Restoration of the East Front of the Temple of Diana at Ephesus, by Dr. Murray.

The Siphnian treasury is supposed to date from the end of the 6th cent. B.C.; in the magnificent carving of the architectural ornament it may be said to rival that of the Erechtheum. Although built in Parian marble, it was richly decorated in colour, of which vivid traces still exist. Among other finds were the remains of four caryatid figures of colossal size, each with a calathos or polos on the head; these, according to Mr Homolle, seem to have supported a tribune like the caryatid portico of the Erechtheum, and probably served as the prototype of the arrephoroi of that building. Further remains have been found of the Sphinx of archaic character, and of the Ionic capital of early date which carried it, sufficient now to complete their restoration. The remains also of a triangular votive column were found, triangular in the sense that as it supported originally a tripod there were three caryatid figures at the top carrying the same; and the decorations of the column, with widely-projecting and finely-carved acanthus leaves, are grouped in triplets, which constitute the capital and base of the column. These acanthus leaves are the earliest known, and are certainly the most vigorous examples ever carved.

At Epidaurus, where excavations were systematically begun in 1881 by the Greek Archæological Society under Mr Kavvadias, the sacred temenos has been laid bare, exposing the plans of the stoa or colonnade where the patients were housed, of the temple of Asclepius (singular in having no epinaos), and of the famous Tholos by Polycleitus the Younger, a circular building with a peristyle of twenty-six Doric columns round the exterior, and a circle of fourteen Corinthian columns inside, the capitals of these columns in Parian marble being of great beauty and among the earliest Corinthian examples known. The famous Theatre has also been cleared out, displaying a circular orchestra and the foundations of a stage of late date, which, from the remains found, seem to have been 12 feet high, with the front decorated with Ionic semi-detached columns, all the capitals having angle volutes (Fig. 4).

The researches made since 1885 on the Acropolis of Athens have resulted in discoveries of more value to the archæologist than to the architect. The foundations of the old Temple of Athene, destroyed by Xerxes in 479 B.C., have been found close to the Erechtheum, and below the level of the same were discovered two stone bases considered to have supported the wooden pillars of the House of Erechtheus. In 1884-86 Mr F. C. Penrose undertook for the Dilettanti Society a series of investigations relative to the Olympieion or temple of Zeus Olympios, which proved that the temple had eight columns in front and rear, and not ten, as had been thought, owing to a misreading of Vitruvius; that the fifteen columns which remain belong to the edifice designed by Cossutius, the Roman architect, 174 B.C., and that Hadrian's share in the work was confined to the completion of the structure, including the new columns in the cella, the original examples having been carried away by Sulla for the decoration of the Temple of the Capitol at Rome. Mr Penrose arrived at his conclusions from the great beauty of the Corinthian capitals of the Peristyle, many of which he thought were of a purer type than any likely to have been carved during the reign of Augustus when the work of completion of Cossutius's temple was again taken up, and still less likely to be of Hadrian's time.

The main results of the late Mr Wood's discovery of the site and remains of the Temple of Diana at Ephesus were made known as far back as 1876. Since then the remains brought to England and placed in the British Museum have attracted the attention of many archæologists, who have attempted to make restorations of the plan embodying the chief features. Amongst these, by far the most trustworthy and most important has been that put forward by Dr Murray in a communication to the Royal Institute of British Architects in 1895. The same paper contains drawings representing a restoration of the carved drum of one of the columns belonging to the archaic temple, built 560 B.C., of which Crœsus contributed most of the cost. By a fortunate accident the lower part of this drum is inscribed with his name. The fragments found have been set up in the Museum, and are interesting as showing the first conception of a scheme of decoration which exists in no other Greek temple. The Ionic capital of this archaic temple was brought over by Mr Wood, and the oblong form of its abacus is an additional proof of the theory which is now held that the Ionic capital was originally what is known as a bracket-capital, copied from the oblong piece of timber placed on a pillar to support the wooden architrave of a portico.

Returning to the later Temple described by Pliny, the two most difficult problems were—(1) where to place the square sculptured pedestals, and (2) how to dispose of the thirty-six "columnæ cœlatæ" spoken of by Pliny. Dr Murray solves the problem by placing the square pedestals (the cornices of which range with the raised platform on which the temple was built), eight at the east and eight at the west end, on a stylobate of four steps, which were carried round the whole building. On these pedestals he places sixteen of the "columnæ cœlatæ"; of the remaining twenty he places eight at the east and eight at the west end behind those raised on the square pedestals, resting on the stylobate of the platform; and the remaining four he places in antæ to the pronaos and epinaos. The nine steps required to reach the platform (there were thirteen in all) Dr Murray puts between the first and second rows of columns of the east and west porticoes (Fig. 5). In determining the plan of the temple, he arranges a vestibule beyond the pronaos, the west wall of which was found by Mr Wood. Then follow the cella, with its double row of columns inside to assist in carrying the roof, and behind it the opisthodomus and the epinaos or posticum (Fig. 6).

The excavations made by the British School at Athens in 1890-91 at Megalopolis have exposed the principal portions of the theatre said by Pausanias to have been the largest in Greece, and have enabled the explorers to trace the plan of the Thersilion or Assembly Hall of the 10,000 Arcadians. The hall covered an area of 35,000 square feet, and is remarkable for its plan, inasmuch as the columns which crowned its roof and which were on three sides of the hall were placed so as to radiate towards the tribune, and thus form the least possible obstruction to the view from any portion of the hall. The bases of the columns, which alone remained *in situ*, proved also by their levels that the floor of the assembly hall sloped towards the tribune. The intercolumniation of the columns varied from 29 to 17 feet, which shows that they carried wooden beams only. The columns were probably in stone, but no remains of any capitals were found. In front of the hall was a portico of sixteen Doric columns, fourteen in the front and one behind each of the angle columns.

The complete excavation of the temenos at Eleusis by the Archæological Society of Athens in 1883 has solved the problem relative to the exact plan of the Hall of the Mysteries. Three successive buildings have occupied the site, and additions and restorations were made to the third hall, designed about 420 B.C. by Ictinus, the architect of the Parthenon. The foundations of the third hall show that the building was 183 feet square, with forty-two columns ranged in seven rows of six each; round the walls were rock-hewn steps for the spectators. The Doric portico of fourteen columns, twelve in front and two behind the angle columns, was added by Philon, the architect of the Arsenal of the Piræus, about 310 B.C. No architectural remains of the hall were found. The temenos was entered through two Propylæa, the outer one of which was hexastyle and similar in plan to the Propylæa at Athens.

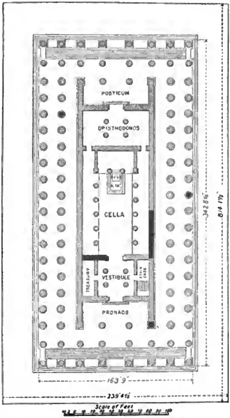


FIG. 6.—Plan of the Temple of Diana at Ephesus.

The sanctuary of the Temple of Apollo in the island of Delos was explored by the Archæological Society of Athens in 1877-83, under the direction of Mr Homolle. The whole site has been cleared, revealing, as at Olympia and Delphi, the foundations of all the temples, treasuries, and other votive monuments. Of the temple of Apollo sufficient was found to enable a complete conjectural restoration of it. It was of the Doric order, but the columns were not fluted.

In 1879-86 the German Government carried out excavations at Pergamon in Asia Minor, under the direction of Herr Humann. Although of comparatively late date, for the principal monuments of the acropolis were only commenced by Eumenes II., 191-159 B.C., the sculpture of the great altar of Zeus, now in the Berlin Museum and representing the battle of the Gods and the Giants, is of exceptional vigour and magnificence, and the splendour of the series of temples raised on successive terraces seems well to have merited the praise of Pliny, who calls it "the most celebrated town in Asia." The principal monument, of which the remains were found, was that of the great altar of Zeus, which was raised on a platform 93 × 90 feet, and 20 feet high, round which at a height of 8 feet from the level of the terrace was carried the great frieze of the "gigantomachia," 7 feet high. A wide flight of steps led up to the altar, which was surrounded by an Ionic peristyle open on the front and three sides; on the walls of the court enclosing the altar was a smaller frieze. On a terrace beyond were the remains of the Doric temple of Athene Polias, with a porticus round two sides of the court, and beyond, the famous Library and the Temple of Rome and Augustus. In the side of the hill was the Theatre, with the great Terrace, terminated at the north end by a beautiful Ionic temple.

Roman.

The immense difference between the levels of ancient and modern Rome, in some cases amounting to from 65 to 70 feet, and the extensive area of the archæological stratum (at least 9 square miles), give some idea of the immense labour and cost of investigations in Rome. Since 1871, according to Professor Lanciani, an area of about 4 square miles has been turned up, with results of the greatest interest and value. Foremost amongst these must be placed the excavations on the Palatine, which have revealed the plans of the greater portions of the palaces built by succeeding emperors. The platform of the hill was selected by Augustus first for his imperial residence. Tiberius, Caligula, and Nero added considerably to it. The Flavian emperors united the various portions built by raising structures between those already erected, and rebuilt the House of Augustus, which had been destroyed by fire; and Septimius Severus added largely at the south-east angle of the hill. The excavations were begun by Napoleon III. in 1860, and since 1871 have been carried out by the Italian Government. The palace begun by Vespasian and completed by Domitian, being destined for state receptions and banquets, was in some respects the most magnificent. The throne room was 160 feet long and 120 feet wide, with a vault the clear span of which exceeded 100 feet. Twelve immense columns of pavonazzetto marble and giallo antico assisted in carrying the vault, and flanked the great doorways and niches; the latter, with smaller columns of porphyry on the east side, held colossal statues or groups, many of which now enrich various museums.

Next in interest come the excavations made on the line of the Via Sacra, which since 1882 has been laid bare from the Forum to the Colosseum. Many of the buildings on either side have always been known; but the removal of the superincumbent earth has not only exposed the bases of the same, but brought to light the complete plans, and in some cases the architectural remains of other structures, such as the Basilica Julia, the Rostra on the Forum, the Temple of Vesta, the house of the Vestal virgins, the Porticus Margaritaria, and the temple of Venus and Rome with its surrounding Porticus, &c. Of these the most interesting was the "Atrium Vestæ," the house of the Vestals, excavated in 1883-84, which has proved to be the most important example of domestic architecture yet found, surpassing in completeness any of the Pompeian houses in consequence of its having a great portion of the upper storey preserved. According to Dr Middleton, the house was evidently rebuilt by Hadrian on a much enlarged scale. It consisted of a large open peristyle measuring 200 feet by 72 feet in two storeys, with rooms in the rear, and at one end the tablinum covered over with a semicircular barrel vault. The whole house was richly ornamented, the floors and walls being covered with Oriental marbles, of which numerous remains were found. The upper part of the walls was decorated with mosaic of coloured glass tesseræ. Staircases were found leading to the upper storey, in which the bedrooms and bathrooms were placed; the walls were lined with marble slabs in the lower part, and above were painted in brilliant colours with panels, wreaths, and garlands.

One of the most valuable discoveries made in Rome of late years is that relating to the date of the Pantheon, which has always been a much-contested point among archæologists. In consequence of serious cracks in the dome which had allowed the rain-water to penetrate though the vault, Mr Chedanne, Grand Prix of the French Academy at Rome, was allowed to make use of the scaffolding which had been erected in 1892 and examine the structure of the vault. On taking out some of the bricks he found them stamped with dates of the time of Hadrian. This led to a further examination of bricks in other parts of the building, on which in every case Hadrian stamps were found, the dates extending from A.D. 115-125. This decided the question at once that the circular portion of the Pantheon was built by Hadrian. Further researches showed that 6 feet below the existing pavement was another pavement of marble which sloped from the centre to the circumference, belonging, therefore, to a circular area exposed to rain; and outside the walls of the existing building, concentric with them, and on the same level as this pavement, was a circular wall of masonry of early date surrounding this open area. A similar pavement was found under the Portico and, at a lower level 3 feet under this, was found another pavement, and a substructure in travertine masonry, larger and of different design. The results of these discoveries are considered to prove that —(1) the original Temple of Agrippa was rectangular; (2) the Portico of Agrippa faced the south instead of the north (which is the aspect of Hadrian's Portico); (3) the original Portico was decastyle, viz., with ten columns in front; (4) the rectangular temple on plan resembled the temple of Concord, the front being on the longer side; (5) not only were the columns of Agrippa's portico used again by Hadrian, but also portions of the entablature and pediment; and (6) in front of Agrippa's temple was an immense circular area surrounded by a wall. This latter suggests that Hadrian or his architect, having this site to build on, conceived the notion of covering the whole area and making the building circular.

Of the later discoveries at Pompeii, those made in 1894-95, when the House of the Vettii was excavated, are by far the most important. The house is comparatively small in size, but in the preservation of its peristyle and its richly-decorated walls it forms the most important representative of its class. It differs in plan from other examples in having no tablinum; the atrium opened directly on to the peristyle. The large room on the north side of the peristyle, richly decorated with cupids and Psyches, may possibly have served as the drawing- or sitting-room of the house.

Origin of the Pointed Arch.—The various theories put forward as to the origin of pointed-arch architecture and its introduction into

Europe through the Crusaders may be considered now as disposed of by the work of M. de Vogué on the churches of the Holy Land, from which it will be seen that they all date from a period long subsequent to the regular employment of the pointed arch and barrel vault in the south of France for constructional reasons. For proper consideration of the question the subject should be divided into two parts—(1) that which has to do with its immediate constructional object; and (2) its constant employment for almost every form of arch and vault during the Middle Ages. The earliest example of the pointed arch known is that found by Professor Flinders Petrie in the Pyramid of Hawara, 2622-2578 B.C. The second was that discovered in the drains of the palace of Khorsabad built by the Assyrians c. 721 B.C. In Egypt its first appearance is in the Nilometer of the Island of Roda, A.D. 861; and after the erection of the Mosque of Tonlon, A.D. 879, it was always employed. From there it was probably imported into Sicily which the Saracens occupied from 941 to 1072. Unfortunately no example of that date remains; but when the Normans conquered Sicily, 1072, they employed the Mahommedan workmen, so that the Saracenic style lingers throughout the buildings erected in Sicily for more than a century. The pointed arch, therefore, was universally adopted in Sicily, and we find it in the church of S. Giovanni de' Leprosi outside Palermo, 1072, and in the Ponte dell' Ammiraglio, built in 1110, the arches of the bridge are of two orders, the lower ring of the arches being recessed slightly behind the upper ring. Of later buildings the church of S. Giovanni degli Eremiti and the Cappella Palatina, both built before 1132, and the church of La Martorana, completed 1143, are all built with pointed arches. Passing now to the south of France, in the church of St Stephen at Périgueux, the western bay, erected 1014, still preserves a portion of its dome and pendentives built on pointed arches. The churches of Brantôme, St Jean de Cole, and Cahors were all built with similar features before the close of the century, and the Cathedral of Angoulême (first bay), and the church of Fontevrault before 1130. It should be pointed out that in the domed churches of Périgord and Angoumois the setting out of the pendentives and its construction in horizontal courses is entirely different from Byzantine dome construction in the East. Throughout Provence the churches were vaulted with pointed-barrel vaults, all in the 11th century, the finest example being that of the church at Carcassonne, 1090.

In Palestine, prior to the crusades, all the doors and windows had circular arches, the vaults only, for constructional reasons, being pointed. The earliest churches built by the Crusaders in Palestine were those of Tortosa and Beyrout, in both of which the naves are covered with pointed-barrel vaults similar to that of Carcassonne, and probably carried out under the direction of the monks of Cluny. From 1142 onwards the Crusaders introduced the dome over the crossing of nave and transepts, pointed arches carrying pendentives and dome, and the construction of the latter is the same as that employed in Périgord, and quite different from that of the Byzantine dome and pendentives of the Greek churches. The arches of the naves of these churches are pointed and of two orders, like the bridge already referred to near Palermo; and the masonry bears so close a resemblance to Sicilian work as to lead us to suppose that Sicilian masons, whose language was either Greek or Arabic, were taken over to Palestine, as they would be better able to direct the native labour of the country. The masons' marks found in the Holy Land are either French or Italian; English or German masons' marks have not been found. There is a natural tendency in M. de Vogué's work to ascribe to French masons the design and erection of all the Crusaders' churches; and in the more important, it is true, we recognize the genius of the French sculptor. The portals of the south doorway of the church of the Holy Sepulchre are identical with examples in the south of France (Fig. 7). On the other hand the mouldings of the west portal of the Church of the Resurrection at Nablûs are of Early English section and associated with the dog-tooth ornament. The only characteristic difference between the Crusaders' churches and those in Europe are that the former have—(1) flat roofs over the aisles and sometimes over the nave, which were possible in the East; and (2) the exterior of the apses was occasionally polygonal, in imitation of those of the Greek Church.

A New Christian Style.—A second work by M. de Vogué on the architecture of Central Syria, published in 1867, revealed the existence of a new Christian style of architecture, religious and secular, hitherto unknown, which, though developed by the Greek Christians of Palestine, is based more directly on the Roman remains in the country. The only parallel to it found in Europe is that which exists in Burgundy in the churches of Autun and Langres, based similarly on Roman work; but there is a difference of five or six centuries in date, and as these towns and villages in Central Syria were deserted during the Mahommedan invasion in the 7th century, and being in the centre of Syria were never even approached by the Crusaders, there can never have been any connexion between the two. M. de Vogué's book is not confined to Christian work. Many earlier buildings of Herodian and Roman work are illustrated in it, and amongst them the stone buildings of the Hauran, which, owing to the absence of timber, are entirely—roofs, doors, and windows—built in stone. These had been visited and described by Burckhart, the Rev. J. L. Porter, and other travellers; but it has only been from the engraved illustrations in M. de Vogué's book that a fair idea has been given of their design and remarkable construction.

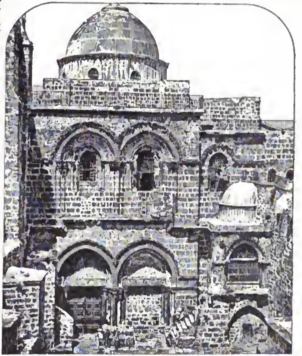


FIG. 7.—South Doorway of the Church of the Holy Sepulchre, Jerusalem.

St Mark's, Venice.—Discoveries in the archives of Venice since 1890 have led to a revised date being given for the construction of the five domes within the basilican church of St Mark's, Venice, restored only by Orseolo in 976. The late Professor Cattaneo arrived at the conclusion that these domes were not built till 1063. It follows, therefore, that the five-domed church of St Front at Périgueux, which was copied from it, is not the first domed church in France, as St Stephen's in Périgueux, and other domed churches, were built in the first half of the 11th century. A more careful examination of the so-called Latin church which stands on the western side of the five-domed church at Périgueux, has revealed features dating from the first half of the 11th century, so that this was the church burnt down in 1120. Moreover, the five-domed church is entirely in stone, so that no such conflagration could have taken place as is recounted in the chronicle. From the fact that the bodies of the saints were not brought back till 1171 to be placed in the new church of St Front, it is probable that it was not commenced till 1160; and this is borne out by the excellence of the masonry throughout, which presented a marked contrast with that of St Stephen's, built in 1014. Instead of being the first domed church therefore, it was the last, of any magnitude.

The following additions require to be made to the glossary given in the ninth edition:—

Apophyge—(a) the inverted cavetto or concave sweep taken by the lower part of the shaft in the Ionic and Corinthian orders before its junction with the base. (b) The hollow or scotia beneath the Doric echinus forming the junction between the capital and the shaft.

Atrium—(a) the open court of a Roman house, surrounded by a colonnade or partially roofed over by projecting eaves. (b) The court in front of a church, surrounded by colonnades or arcades.

Cella, the sanctuary of a Greek or Roman temple, enclosed by walls and entered from the pronaos = *ναός* in Greek.

Epinaos, the open vestibule behind the naos or cella, sometimes called the opisthodomus, as it was occasionally enclosed with metal grilles and contained the properties of the temple.

Helix, term given to the spiral of the Ionic volute and the tendrils of the Corinthian capital.

Opisthodomus (Greek, from *ὄπισθεν*, behind, and *δόμος*, a house), an enclosed chamber behind the naos and entered from the epinaos, employed to store the treasury of the temple.

Porticus, a building with its roof supported by one or more rows of columns, either in one straight line or enclosing a space (Greek, *στοά*).

Stereobate, the substructure of rough masonry beneath a temple.

Stylobate, the upper of the three steps on which the Greek temple stands; generally applied to the three steps.

Temenos, the sacred enclosure round a temple.

Tholos, term given to Greek circular buildings with or without a peristyle.

Velarium, the curtain or awning extended above the auditorium of the Roman theatre to protect the spectators from sun or rain.

Xoanon, a rude and primitive image carved in wood.

Zoophorus, a continuous frieze sculptured in relief, with the figures of human beings and animals. (R. P. S.)

Arcot, a town of British India, which gives its name to two districts in the Madras presidency. The town has now lost its manufactures and trade, and preserves only a few mosques and tombs as traces of its former grandeur.

The district of North Arcot has an area of 7616 square miles. In 1891 its population was 2,180,487, being 286 persons per square mile; in 1901 the population was 2,208,391, showing an increase of 4 per cent. The administrative headquarters are at Chittur, but the largest towns are Vellore (the military station), Tirupati (a great religious centre), and Wallajapet and Kalahasti (the two chief places of trade). The land revenue and rates in 1897-98 were Rs.32,60,842, the incidence of assessment being Rs.2:7:0 per acre; the cultivated area was 828,396 acres, of which 366,245 were irrigated, including 49,783 from government canals; the number of police was 1284; the boys at school in 1896-97 numbered 42,509, being 26 per cent. of the male population of school-going age; the registered death-rate in 1897 was 20·2 per thousand.

The district of South Arcot has an area of 5217 square miles. In 1891 its population was 2,162,851, being 414 persons per square mile; in 1901 the population was 2,350,365, showing an increase of 9 per cent. The administrative headquarters are at Cuddalore, close to the site of Fort St David. The land revenue and rates in 1897-98 were Rs.45,82,820, the incidence of assessment being Rs.2:7:9 per acre; the cultivated area was 1,456,961 acres, of which 470,353 were irrigated from tanks, &c., including 141,210 from government canals; the number of police was 963; the boys at school in 1896-97 numbered 36,464, being 22·5 per cent. of the male population of school-going age; the registered death-rate in 1897 was 21·2 per thousand. The principal crops in both districts are rice, millet, other food grains, oil-seeds, and indigo.

Arctic Ocean. See Polar Regions.

Arctic Regions. See Polar Regions.

Arcueil, a town of France, department of Seine, in the arrondissement of Sceaux, and 2½ miles N.E. of that town, on the railway from Paris to Sceaux. It takes its name from a Roman aqueduct, the *Arcus Juliani*, some traces of which still remain. Two superimposed aqueducts now supply water to Paris. Starch, vermicelli, bottle capsules, patent leather, and other articles are manufactured. There are important quarries. Population (1881), 5529; (1891), 5863; (1896), 6418, (comm.) 6494.

Ardebil, or Ardabil, chief town and seat of government of a district, or sub-province of the province of Azerbáiján, in north-western Persia, in lat. 38° 14′ N., long. 48° 21′ E., and at an elevation of 4500 feet. It is situated on the Baluk Sú (fish-river), a tributary of the Kara Sú (Black river), which flows northwards to the Arras, and in a fertile plain bounded on the west by the Savalán Dágh, a volcanic mountain with an altitude of 15,792 feet (Russian triangulation). Ardebil has a population of about 10,000, a garrison of half a battalion of infantry, and post and telegraph offices. Its trade, principally in the hands of Armenians, is still important, but is chiefly a transit trade between Persia and Russia by way of Astara, a port on the Caspian 30 miles N.E. of Ardebil (Dr F. Sarre, "Reise von Ardebil," &c., in *Petermann's Mitteilungen*, September 1899). Plans and photographs of the shrine and mosques were taken in 1897 by Dr F. Sarre of Berlin.

European and Chinese merchants resided at Ardebil in the Middle Ages, and for a long time the city was a great emporium for Central Asian and Indian merchandise, which was forwarded to Europe by way of the Caucasus and the Volga, and also *viâ* Tabriz and Trebizond. Since the 16th century, when Persia fell under the sway of the Safavi dynasty, the place has been much frequented by pilgrims, who come to pay their devotions at the shrine of Shaikh Safi, the ancestor of Shah Ismail, who was the founder of the dynasty, and the shrine is a richly-endowed establishment, with mosques and college attached. It had also a fine library, containing many rare and valuable MSS. presented by Shah Abbas at the beginning of the 17th century; but most of these MSS. were carried off by the Russians in 1828, and are now in St Petersburg. The grand carpet, which had covered the floor of one of the mosques for three centuries, was purchased by a traveller some years ago for about one hundred pounds, and was finally acquired by the South Kensington Museum for many thousands.

Ardèche, a department of the S. of France, traversed by the Cevennes and watered by the Rhône and its affluent the Ardèche.

Area, 2145 square miles, with 31 cantons and 339 communes. The population declined to 375,472 in 1886, 363,501 in 1896, and 349,961 in 1901. In 1899 the births numbered 8465, of which 170 were illegitimate, the deaths 8437, and the marriages 2625. The chief towns are Privas (7843 inhabitants in 1896), Largentière, Tournon, and Annonay. In 1896 there were 1171 primary schools, with 61,178 pupils; 8 per cent. of the population was illiterate. The surface under cultivation comprised 938,499 acres, or more than three-fifths of the department, but the plough-land made up only 480,871 acres. The vine, attaining a fair range of cultivation, had 36,628 acres. In 1899 the wheat crop reached the value of £247,625, and the vine about a seventh more. Ardèche is one of the departments in which the mulberry grows most abundantly. The crop of leaves amounted in 1899 to nearly 73,000 cwts., and sericulture has developed in proportion, yielding 33,000 cwts. of cocoons, of the value of about £199,000. There were 25,000 sericulturists, and only Drôme and Gard have a greater number. The live stock in 1899 numbered 14,170 horses, 10,450 mules and asses, 97,760 cattle, 229,690 sheep, 102,140 pigs, and 128,580 goats. The mining production is inconsiderable, yielding in 1898, 50,000 tons of coal and 48,000 tons of iron. The working in metals realized in 1898 only some 23,000 tons of iron. The principal industries are paper manufacture (Annonay), tanning, and weaving.

Ardennes, a department in the N.E. of France, bordering on Belgium. It is covered with the wooded mountains of Ardennes, and traversed by the Meuse, the Semoy, and the Aisne.

Area, 2028 square miles, distributed among 31 cantons and 503 communes. The population decreased from 332,759 in 1886 to 315,589 in 1901. Births (1899), 6523, of which 492 were illegitimate; deaths, 6754; marriages, 2437. The principal towns are Mezières, which, with Charleville, has a population of more than 25,000 souls, Sedan, Rethel, Vouziers, and Rocroi. In 1898 there were 833 schools, with 43,815 pupils. Two per cent. of the population was illiterate. The total surface under cultivation comprised 1,224,455 acres, but the forests alone occupied 271,700 acres, and the plough-land was confined to 669,370 acres. The climate does not allow the cultivation of the vine. In 1899 wheat yielded a value of £748,678. Oats also gave excellent returns. Among the industrial cultures, beetroot is alone deserving of notice, producing in 1898, 2,090,585 cwts. In 1899 the live stock amounted to 47,370 horses, 109,040 cattle, 271,950 sheep, and 49,890 pigs. There are no coal-pits in the department of Ardennes, but iron-mines are found between Mezières and Rethel. The valley of the Meuse produces enormous quantities of slate. The working of metals (nails, bolts, machines) is highly developed all along the valley of the Meuse (Monthermé, Revin, Givet), yielding in 1898, 96,000 tons of cast iron and of iron, and 46,000 tons of steel, of the value of £995,000. The produce of the other metals amounts to the value of £255,000. Sedan is celebrated for the making of cloth. In the production of sugar, Ardennes takes the eighth rank among the departments, yielding in 1898, 255,893 cwts.

Ardglass, a village in the county of Down, Ireland, 7 miles S.S.E. of Downpatrick, with which it is now connected by a light railway. It is noted for its herring fisheries, the quantity caught in 1899 having been 15,519 cwt., valued at £5744. Population, 554.

Ardmore, a town of Chickasaw Nation, Indian Territory, U.S.A., situated on the Gulf, Colorado, and Santa Fé railway, at an altitude of 870 feet. Like other towns of this territory, it has no corporate existence, nor are any lots owned in fee by the occupants, with the exception of those lying within the right of way of the railway. The site was originally a squatter's claim, and lots are held by quit-claim deeds or leases under it. The population consists almost entirely of whites, the Indians keeping remote from the railway and large towns. The adjacent region is a rich farming country, producing cotton, grain, and cattle, with the shipping of which the town is mainly concerned. Population (1900), 5681.

Ardrossan, a seaport, burgh of barony, and police burgh of Ayrshire, Scotland, 14½ miles N.N.W. of Ayr by water. It has stations on the Glasgow and South-Western and Lanarkshire and Ayrshire railways. The dock accommodation has been greatly extended. In 1898 the port register contained 63 vessels of 25,129 tons; and the tonnage entered was, in 1888, 2429 vessels of 247,425 tons; 1898, 3440 vessels of 734,320 tons; cleared in 1888, 2347 vessels of 243,398 tons, and in 1898, 3393 vessels of 737,155 tons. Imports were valued at £66,540 in 1888, and £463,015 in 1898; exports at £12,919 in 1888, and £202,068 in 1898. In 1898, 477,082 tons of coal were exported and 60,351 tons of iron. One of the public schools is an academy. Population (1881), 4098; (1891), 5294; (1901), 5933.

Arecibo.—A city near the west end of the north coast of Porto Rico, founded in 1788. It commands the trade of the adjacent portions of the island, and ships large quantities of sugar and coffee. Near by are the famous caverns of Consejo. The harbour is poor. Population (1899), 8008.

Arendal, or ARNDAL, a seaport town of Norway, co. Nedenäs, on the S. coast, 36 miles N.E. from Christiansand. It possesses a relatively large commercial fleet (212 vessels of 117,250 tons aggregate), principally engaged in exporting timber (2 to 2½ million cubic feet annually to Great Britain), wood-pulp, sealskins, and felspar. In 1879 Arendal ranked second (after Christiania) as a ship-owning port; in 1899 it had dropped to the fifth place. In and near the town are factories for wood-pulp, paper, cotton, and joinery; and at Fevig, 8 miles to the north-east, a shipbuilding yard and engineering works. Population (1875), 4132; (1891), 4578; including suburbs (1899), about 10,000.

Arequipa, a coast department of southern Peru, containing seven provinces, Arequipa, Camana, Islay, Unión, Caylloma, Condesuyos, and Castilla. Its area occupies 21,947 square miles and its population in 1896 was officially estimated at 229,007. The capital, Arequipa, has a population of 35,000. The foreign trade of the town is carried on by the port of Mollendo, distant ninety miles, with which it is connected by rail (107 miles); the exports are mainly sheep's wool and alpaca, coca leaves, and borate of lime.

Arezzo, a town and episcopal see of Tuscany, capital of the province of Arezzo, 55 miles S.E. from Florence, Italy. The church of St Francis (1322) contains frescoes by Piero della Francesca and Spinello Aretino. Other notable edifices are the churches of SS. Annunziata and Sta Maria della Pieve (11th-14th cent.), the town hall (now converted into a jail), the ceramic Museum Funghini, the house in which Petrarch was born, the house of Vasari, and the municipal museum. There are a technical school and an academy of sciences, arts, and letters. Silks, gunpowder, pottery, and macaroni are manufactured, and tanning and printing are carried on. Population: commune (1881) 38,950, (1901) 44,350; province (1881) 238,744, (1901) 272,359.

Argao.—A town of 34,000 inhabitants, on the east coast of Cebu, Philippine Islands, in latitude 10° 3′ N. It was founded in 1608. Its products are rice, Indian corn, and cacao. The latter is of superior quality and is produced in large quantities. A limited amount of cotton is raised and woven into cloth. The language is Cebu-Visayan.

Argentan, chief town of arrondissement, department of Orne, France, 27 miles N.N.W. of Alençon, on railway from Caen to Mans. One of the two principal churches contains fine wood-carving and 16th-century glass. Manufactures include stained glass. Oolitic limestone, quarried in the vicinity, is used in the construction of local buildings. The historian Mezeray and Charlotte Corday were born here. Population (1876), 4831, (comm.) 5365; (1896), 5070; (1901), 6291.

Argenteuil, a town of France, department of Seine-et-Oise, arrondissement of Versailles, 3¼ miles N.W. of outer circle of Paris, on railway from Paris to Mantes. Asparagus and figs are cultivated in the district, and heavy iron goods, chemical products, and plaster are manufactured. At CHOIX-DU-DÉSERT, between Argenteuil and Epernay, a large tumulus was opened in 1866, and found to contain over 200 skeletons, and a large quantity of arms and utensils. Population (1881), 9456; (1891), 11,362; (1896), 13,847; (1901), 17,424.

Argentine, a city of Wyandotte county, Kansas, U.S.A., situated in the eastern part of the state, five miles west of Kansas City, Missouri, on the south bank of the Kansas and just above its mouth, in 39° 04′ N. lat. and 94° 38′ W. long., at an altitude of 750 feet. Its streets run irregularly up the steep face of the river bluffs. It is entered by the Atchison, Topeka, and Santa Fé railway. Its chief business is the smelting of ores of the precious metals, lead, and copper from mines in the Rocky Mountains. Population (1890), 4732; (1900), 5878.

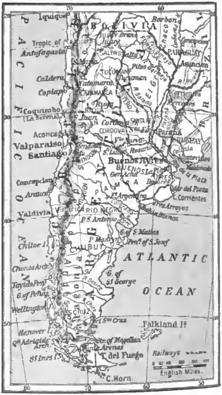
ARGENTINE REPUBLIC.

I. Geography and Statistics

Boundaries.

THE only considerable portion of the Argentine inland frontier which has not been in dispute in recent years is that formed by the lower waters of the river Uruguay, separating it from the Uruguayan Republic and the southern portion of Brazil. In accordance with a treaty of 1889 between the Argentine Republic and Brazil, and the arbitration award made by President Cleveland of the United States in 1894, the boundary line leaves the Uruguay river at its confluence with the Pequiry, and after ascending this stream northwards passes in a straight line to the source of the San Antonio, which it descends to its confluence with the Iguassu, and thence to the confluence of the Iguassu and Paraná. From this point the Argentine and Paraguayan Republics are conterminous. The boundary, by treaty of 3rd February 1876, follows the course of the Paraná to its junction with the Paraguay, which it ascends as far as the mouth of the Pilcomayo river. Formerly the Argentine Republic claimed territory north of the Pilcomayo, while the Paraguayan Republic asserted that the Bermejo was the boundary river; but by the treaty of 1876 and the arbitration award of President Hayes of the United States, given on 13th November 1878, the frontier line ascends the Pilcomayo as far as the frontier of Bolivia. The Argentine-Bolivian boundary (demarcated in accordance with the treaty of 1889) starts from the point where the Pilcomayo cuts the parallel of 22° S. lat., and runs due west to the Tarija, which it descends to the Juntas de San Antonio, whence it ascends the Bermejo. Leaving this river it proceeds to the Quiaca ravine, and thence to a point on the San Juan river opposite Esmoraca. After ascending the San Juan, it runs to the Cerro de Granados, to Incahuasi, and to Sapalegui on the Chilian frontier. The Argentine-Chilian frontier is still, for the most part, undetermined. On 17th April 1896 an agreement was signed providing for its delimitation as far south as the parallel of 52° S. lat., "the crests of the Andes that form the watershed" being stated as defining the boundary line. From 23° to 26° 52′ 45″ S. lat. the demarcation has been carried out, but in its continuation southwards disputes arose which were referred for arbitration to the British Government. At a point in 52° S. lat. the boundary (in accordance with a treaty with Chile, made in 1881) runs eastwards till it reaches the meridian of 70° W. long., and then south-eastwards to Cape Dungeness, at the eastern entrance of the Strait of Magellan. On the opposite side of the strait, which, by the treaty, is neutralized and free to the ships of all nations, the boundary lies in the meridian of 68° 34′ W. long. from Cape Espiritu Santo to Beagle Channel, and then follows the channel to the Atlantic. The portion of Tierra del Fuego, and some small islands, including Staten Island, lying to the east of this line, belong to the Argentine Republic; the land and islands to the west and south belong to Chile.

Climate.—In the riparian provinces of Buenos Ayres and Santa Fé there are great areas of almost flat land, which consists of deep, rich loam formed from the alluvial deposits of the Rio de La Plata and the Rio Paraná, and which for stock-breeding and agricultural purposes cannot be surpassed. A temperate climate is not the least of the many advantages this section of the country can claim, for an average rainfall of some 34 inches provides abundant moisture for vegetation, and the many days of bright sunshine ensure the ripening of the cereal crops. The southern portion of the province of Cordova, closely resembling the provinces of Buenos Ayres and Santa Fé, likewise contains large areas of arable land. These three provinces have other important features. In the south of Buenos Ayres is the Sierra Ventana, an extensive mountain range; the north-east of Santa Fé contains much valuable timber; in the northern and eastern sections of Cordova are great mountainous areas, the mineral wealth of which was worked by the early Spanish settlers. The climate of the Andean provinces of Mendoza and San Juan is eminently suitable for the cultivation of the vine. The valleys of the Andes open out at Mendoza into plains requiring only irrigation to produce abundant vegetation; the rivers, supplied by the melting snows at the higher elevations, provide the necessary water, and every year the area of cultivation increases. On these plains there is a rainfall of only six inches annually, snow rarely falls, and frosts are never severe. To the north of San Juan are the provinces of La Rioja and Catamarca, mountainous and heavily wooded, and intersected with well-watered, fertile valleys. Between Cordova and Tucuman are great saline plains covered with a white alkaline crust, which glitters in the sunlight like an inland sea. At Tucuman tropical vegetation appears, although frosts occur regularly in winter, not however of sufficient severity to prevent the growth of the sugar-cane. Salta and Jujuy, situated farther north amongst the wooded spurs of the lower Andean ranges, possess a climate tropical in the valleys, temperate on the higher plateau. To the north-east of Salta, and bordering on the republic of Bolivia, is the territory known as the Chaco, where the characteristic features are dense tropical forest interspersed with open, park-like grass-lands. Still farther to the east, and adjoining Paraguay and Brazil, is the territory of the Misiones, covered with tropical jungle and watered by the river Uruguay, which passes in enormous volume over the Iguassu Falls and ultimately forms, with the Rio Paraná, the great estuary of the river Plate. The southern



MAP OF THE ARGENTINE REPUBLIC.

territories of Argentina, comprising the basin of the Rio Negro, the district of Neuquen, and the little-known land of Patagonia, through which the Chubut, Santa Cruz, and Gallegos rivers flow to the Atlantic, are of a very different character (see PATAGONIA). From Neuquen southwards along the eastern slopes of the Andes lie valleys of great fertility, with magnificent timber on the mountain sides, and a series of great lakes beginning at Nahuelhuapi, the headwaters of the Rio Limay, extends some 500 miles towards the Strait of Magellan. In the centre of Patagonia, where the steppes open out into rolling grass-land, heavy snowstorms and a low temperature generally prevail during the long winter, from May to the end of September. Near the Atlantic seaboard the climate again becomes more temperate. From Chubut to the Strait of Magellan snow falls frequently in winter, but not, as a rule, in sufficient quantities to interfere seriously with pastoral and agricultural industry.

Harbours.—In spite of some natural disadvantages Buenos Ayres remains, and will probably long remain, the principal port of Argentina, on account of the convenient and commanding position it holds for the river trade. Rosario and Santa Fé are centres of great grain-growing districts, and large quantities of wheat are annually shipped from them direct to Europe. Six hundred miles to the south of Buenos Ayres is the port of Bahia Blanca, with a shipping trade which might be largely increased by a comparatively small expenditure on the harbour works. Still farther to the south, and only some 20 miles distant from the mouth of the Rio Negro, is the natural harbour of San Blas. Near the Chubut river is Port Madrin, and between that place and the Strait of Magellan are harbours at the mouths of the Santa Cruz and Gallegos rivers.

Area and Population.—The subjoined table shows the area and population of the republic, and its provinces and territories.

Administrative Divisions.	Area, Square Miles.	Pop. 1895.	Pop. per Square Mile.
Provinces.			
Buenos Ayres	117,850	1,585,022	13
Santa Fé	50,915	397,188	7
Entre Rios	28,784	292,019	10
Corrientes	32,579	239,618	7
Cordova	62,160	351,223	6
San Luis	28,534	81,450	3
Santiago	39,764	161,502	4
Mendoza	56,501	116,136	2
San Juan	33,715	84,251	3
Rioja	34,546	69,502	2
Catamarca	47,532	90,161	2
Tucuman	8,926	215,742	24
Salta	62,185	118,015	2
Jujuy	18,975	49,713	3
Territories.			
Misiones	11,282	33,163	3
Formosa	41,401	4,829	...
Chaco	52,741	10,422	...
Pampa	56,320	25,914	...
Neuquen	42,345	14,517	...
Rio Negro	75,924	9,241	...
Chubut	93,427	3,748	...
Santa Cruz	109,142	1,058	...
Tierra del Fuego	8,298	477	...
Total	1,113,846	3,954,911	3
Population not in census	...	60,000	
Indian population	...	30,000	
Total	...	90,000	
Grand total	...	4,044,911	

In 1869 the population was 1,830,214, showing an average annual increase up to 1895 of 4·98 per cent. Of the total population in 1895, 2,088,919 were males and 1,865,992 females. The foreign element numbered 1,004,527, of whom 492,636 were Italian, 198,685 Spanish, 94,098 French, 48,650 Uruguayan, 24,725 Brazilian, 21,788 British, 20,594 Chilian, 17,143 German, 15,047 Russian, 14,789 Swiss, 14,562 Paraguayan, and 12,803 Austrian, many other nationalities being represented by smaller numbers.

Immigration and Emigration.—In the 43 years, 1857-99, 2,564,391 immigrants entered, and 882,599 emigrants departed from the ports of the republic. In the 10 years, 1880-89, the arrivals and departures were respectively 1,020,907 and 175,038; in 1890-99, 928,865 and 552,175. In 1899 the immigrants by ocean steamers numbered 84,442, and the emigrants 38,397. In 1900 the numbers were respectively 84,851 and 38,334. In 1900 there were 52,148 immigrants from Italy, 20,383 from Spain, 3160 from France, 2119 from Russia, and 2024 from Austria. In 1897, 27,593 availed themselves of the immigration laws with respect to taking up public lands. Owing to the buying up of accessible land by corporations and speculators the central and southern provinces have, so far, not attracted colonists.

Chief Towns.—The principal towns are as follows:—

	Population.		Population.
Buenos Ayres (1900)	824,303	Corrientes	16,129
Rosario	91,669	Chivilcoy	14,632
Cordova	47,609	Gualeguaychú	13,282
La Plata	45,410	San Nicolas	12,550
Tucuman	34,305	Concordia	11,695
Mendoza	28,302	Rio Cuarto	10,825
Paraná	24,098	San Juan	10,410
Santa Fé	22,244	Barracas al Sur	10,185
Salta	16,672		

Constitution and Government.

The present constitution of the Argentine Republic dates from 25th September 1860. The legislative power is vested in a Congress of two chambers—the Senate, composed of members (two from each province and two from the capital) elected by the provincial legislatures for a term of nine years, and the Chamber of Deputies, elected for four years by direct vote of the people, one deputy for every 20,000 inhabitants. To the Chamber of Deputies exclusively belongs the initiation of all laws relating to the raising of money and the conscription of troops. It has also the exclusive right to impeach the president, vice-president, Cabinet ministers, and federal judges before the Senate. The executive power is exercised by the president, elected by presidential electors from each province chosen by direct vote of the people. The president and vice-president are voted for by separate tickets. The system closely resembles that followed in the United States. The president must be a born citizen of the Argentine Republic, a Roman Catholic, not under thirty years of age, and must have an annual income of at least $2000. His term of office is six years, and neither he nor the vice-president is eligible for the next presidential term. All laws are sanctioned and promulgated by the president, who is invested with the veto power, which can be overruled only by a two-thirds vote. The president, with the advice and consent of the Senate, appoints judges, diplomatic agents, governors of territories, and officers of the army and navy above the rank of colonel. All other officers and officials he appoints and promotes without the consent of the Senate. The Cabinet is composed of five ministers—the heads of the Government departments of the interior; foreign affairs; finance; war and marine; and justice, worship, and education. They are appointed by and may be removed by the president.

Provincial Government.—The provinces, under the constitution, retain all the powers not delegated to the Federal Government. Each province enacts its own constitution, which must be republican in form and in harmony with that of the nation. Each elects its governor, legislators, and provincial functionaries of all classes, without the intervention of the Federal Government. Each may conclude with the knowledge of the Federal Congress such partial treaties as may be necessary for the administration of justice, the regulation of financial interests, or the carrying out of public works. Each may promote by means of protective laws its own industries, may regulate immigration into its territories, and deal with similar local economic questions.

Justice.—Justice is administered by a Supreme Federal Court of five judges and an attorney-general, which is also a court of appeal, and by a number of inferior and local courts. Each state has also its own judicial system. Trial by jury is established by the constitution, but never practised. Civil and criminal courts are both corrupt and dilatory. In May 1899 the minister of justice stated in the Chamber of Deputies that the machinery of the courts in the country was antiquated, unwieldy, and incapable of performing its duties; that 50,000 cases were then waiting decision in the minor courts, and 10,000 in the federal division; and that a reconstruction of the judiciary and the judicial system had become necessary. In June 1899 he sent his project for the reorganization of the legal procedure to Congress, but no action has yet been taken beyond referring the Bill to a committee for examination and report.

Religion.—The Argentine constitution recognizes the Roman Catholic religion as that of the state, but tolerates all other religions. The state pays the clergy, builds churches, &c., controls all ecclesiastical appointments, and decides on the passing or rejection of all decrees of the Holy See. In 1895 there were 1019 Catholic churches, or one for every 4000 inhabitants. There were also sixty-eight Protestant churches, three masonic halls, one Spiritualists' church, and one Russian Orthodox church. Of the Protestant churches twenty-five are in the territory of Chubut, which was largely colonized from Wales. In 1895 the population was divided as follows, according to religion:—

	Argentine.	Foreign.	Total
Catholics . .	2,944,397	976,739	3,921,136
Protestants . .	5,597	21,158	26,755
Jews . . .	195	5,890	8,085
Others . . .	190	745	935
Total . .	2,950,379	1,004,532	3,954,911

From this it appears that 991 per 1000 are Catholics, 7 per 1000 are Protestants, and 2 per 1000 are Jews, the Jews being entirely of Russian origin, sent into the republic since 1891 by the Jewish Colonization Association.

Education.—The number of schools and colleges in 1899 was 3884, and of professors and teachers 11,001. The number of pupils under instruction was 250,930. Of these 192,060 attended elementary schools, 66,399 private establishments, 13,313 normal schools, and the remainder the higher educational course at the universities and at the various national advanced colleges. The national colleges are sixteen in number, and there are normal schools, a school of mines, a college of agriculture, two military schools (one with 125 cadets, the other for the instruction of non-commissioned officers), and three naval schools (one for officers and two for artificers and mechanics). The national universities are at Buenos Ayres and Cordova, and provincial universities are at La Plata, Santa Fé, and Paraná. The total number under instruction represents only 7 per cent. of the population, as compared with 23 per cent. in the United States and 20·3 per cent. in the United Kingdom. The cost of education to the state in 1899 was extremely heavy, no less a sum than £1,000,000 being devoted nominally to that purpose, an average of nearly £5 for each pupil attending the public educational institutions.

The Army.—The regular army, at the beginning of 1899, consisted of 1463 officers and 12,867 non-commissioned officers and men. In the ranks were then serving 2157 recruits of twenty years of age, drawn under the conscription law in connexion with the liability of Argentine citizens to be called upon for military service. The army comprised one regiment of engineers, two of mountain artillery, six of light artillery, twelve of infantry, eleven of cavalry, and two of Andean sharpshooters. There is also the president's escort. On 31st December 1898 the number of men enrolled in the National Guard, including the entire male population between the ages of eighteen and forty-five years, with certain exceptions, was 233,945 on the list for active service, 90,924 on the reserve list, and 13,780 on the territorial list; 5323 men liable to service were excused on special grounds. The total number of men the Government can call to arms to assist the regular troops is, therefore, 343,972. Under Law No. 3318 all youths of the age of twenty years are required to undergo a regular training and to serve two years in the army, if necessary. In 1898 the number of youths coming under this category was 34,000; but of these only 12,000 underwent the authorized instruction of sixty days with the colours, the remainder not being called out from motives of economy. The main body of the National Guard is paraded and drilled on all holidays and Sundays, attendance being compulsory for two months in every year until a citizen is twenty-five years of age. The number of horses in service in 1899 was 14,432, and of mules 4169. The artillery armament is from Krupp.

The Navy.—A marked development has taken place in the navy since 1874, when the Government ordered from British shipbuilders two ironclads, four monitors, and two gunboats. In 1881 the *Almirante Brown* was purchased in England, and in 1886 the *Patagonia* and *Argentina* were added to the list. In 1892 the *Independencia* and *Libertad* were acquired, then the cruiser *25 de Mayo*, and the *9 de Julio*. The fear of war with Chile induced the purchase of the *Buenos Ayres* in 1896, of the *Garibaldi* in 1897, and of the *San Martin*, *Puerryedon*, and *General Belgrano* in 1898. A torpedo division was also created with four first-class sea-going torpedo boats, two torpedo gunboats, and twenty-one torpedo boats. At La Plata there is a dock for the use of the torpedo division, and on the river Tigre a slip and workshops for repairs have been erected. A school-ship, the *Sarmiento*, has also been added to the navy list. The officers on the list in 1899 numbered 640 of all ranks and classes, and the petty officers and seamen 5105. A naval port is being constructed at Belgrano, some 27 miles from Bahia Blanca, for the use of the men-of-war, and there will be sufficient draught of water at this port to admit the docking of vessels up to 12,000 tons. The estimated cost of the construction of the new port exceeds £1,000,000. The machine guns and rifles now in use in the navy are all of the most recent pattern.

Finance.—The revenue of the republic is derived mainly from customs and excise, and the largest branch of expenditure is the service of the debt. In 1878 the revenue amounted to the equivalent of £3,680,000; in 1881, to £4,260,000, the expenditure in the latter year reaching the amount of £5,670,000. The following table shows approximately the revenue and expenditure in 1893 and onwards, conversions being made at the rate of $5.04 to £1 for gold, and at the average rate of each year for paper. These average rates are shown in the last column of the table. For the years 1900 and 1901 the budget estimates are given:—

Year.	Revenue.	Expenditure.	Paper Dollars to £1.
	£	£	
1893	7,592,880	8,493,220	16.32
1894	6,995,940	8,973,760	17.85
1895	7,555,450	9,479,310	17.50
1896	8,677,140	12,034,200	14.86
1897	10,223,040	12,187,530	14.61
1898	18,872,568	24,044,245	12.95
1899	14,503,140	15,325,230	11.29
1900	12,859,000	12,996,100	11.36
1901	13,078,000	12,975,000	11.36

The abnormal increase of revenue and expenditure in 1898 and 1899 was due to the warlike preparations made on account of the boundary disagreement with Chile. In 1900 a 10 per cent. additional tax, which had been imposed on imports, was abolished to the extent of one-half, the remaining half being made applicable to the formation of a fund for the conversion of the paper money.

The debt of the republic in 1889 amounted to about £24,000,000, and in the following year financial difficulties arose. In 1891 a funding loan, limited to £7,830,680, was issued, and the proceeds were applied to the service of external loans and obligations. In 1893 the Romere arrangement was made between the National Government and the bondholders for the suspension of amortization and the temporary reduction of interest. The payment of full interest was resumed in 1898. In the years 1896-99 the issue of railway guarantee rescission bonds amounting to £11,607,100 was authorized for the purpose of settling railway guarantees in arrears; and in 1897-1900 the issue of bonds amounting to £20,284,600 was authorized, that arrangements might be made between the provinces and municipalities and their creditors. A considerable amount of the public debt arose from national mortgage bank *cedulas*, for which the Government had made itself responsible. In the year 1900 the outstanding and authorized debt of the republic was as follows:—

	£
External debt—	
Original national loans	45,738,708
Assumed provincial, &c.	31,891,657
National *cedulas*	9,945,143
Total external	87,575,508
Internal debt—	
$6,375,000 gold 98,751,300 paper	9,896,384
Floating debt, &c.—	
$23,852,751 gold 9,012,804 paper	5,564,000
Paper currency, $291,326,263	25,600,000

The total obligations of the nation—external, internal, floating, and currency—thus amount to over £128,000,000.

According to an estimate given in the twenty-seventh annual report of the Foreign Bondholders' Council the cost of the service of the whole debt (exclusive of expenses) in 1900 amounted to £6,301,419.

The paper currency forms an important part of the internal debt. By the emission of vast sums of paper money President Celman entered on the course which led to the financial ruin of Argentina, and by further emissions, in reality neither more nor less than forced loans, subsequent presidents hastened the collapse. The assumption by the National Government of the provincial external indebtedness was only an act of justice. These provincial loans were contracted under the law of 3rd November 1887, an Act more commonly known as the Free Banking Law. The various provinces made loans abroad to the amount of £27,000,000, and deposited the specie with the National Government through the Caisse de Conversion, the gold to remain intact as security for the value of the notes issued by the provincial banks. In return for the gold deposited in the Caisse de Conversion the provinces were entitled to receive internal gold bonds bearing 4½ per cent.

interest, the bonds remaining in the custody of the Caisse de Conversion, which was authorized to attend to the annual service. But President Celman sold the gold specie, and the provincial bank notes immediately lost their value. The National Government has to some extent made good the loss caused by the action of Celman.

Minerals.—The principal mineral deposits of the republic are found in the provinces of Sao Juan, La Rioja, Mendoza, Jujuy, Salta, San Luis, and Catamarca, and in the territories of Santa Cruz, Chobut, Pampa, Neuquen, Tierra del Fuego, and Rio Negro, the richest being that of Jujuy. Gold and silver are found in many places, but the only rich deposits now being worked are in the Famatina region in La Rioja. Lead is found in some veins in La Rioja, Cordova, Mendoza, and San Luis. Copper has been discovered in the provinces of San Juan, La Rioja, Cordova, Catamarca, Meodoza, Salta, and Jujoy. Most of the ore contains considerable quantities of gold and silver. Iron, of poor quality, has been found in Mendoza, Cordova, La Rioja, and San Juan, but there are no smelting works in the country. Coal has been discovered in the department of San Rafael in Mendoza, in Neuquen, the Arroyo Malo, and San Juan in the district Morado. Some small petroleum springs have also been discovered in the department of Anta in the province of Salta, and near the town of Oran.

Agriculture and Stock-raising.—In 1878 the production of wheat was insufficient for home consumption, the amount of maize grown barely covered local necessities, and the only market for live stock was in the *saladero* establishments where the meat was turned into jerked beef for the Brazilian and Cuban markets. But three years later the actual economic development began. In 1881 President Roca offered for public purchase by auction the lands in the southwest of the province of Buenos Ayres, the Paropa Central, and the Neuquen district, these lands having been rendered habitable after the campaign of 1878 against the Indians. The upset-price was £80 sterling per square league of 6669 acres, and, as the lands were quickly sold, an expansion of the pastoral industry immediately ensued. The demand for animals for stock-breeding purposes sent up prices, and this acted as a stimulus to other branches of trade, so that, as peace under the Roca régime seemed assured, a steady flow of immigration from Italy set in. The development of the pastoral industry of Argentina since those days has been remarkable. In 1878 the number of cattle was 12,000,000; of sheep, 65,000,000; and of horses, 4,000,000: in 1899 the numbers were—cattle, 25,000,000; sheep, 89,000,000; and horses, about 4,500,000. Originally the cattle were nearly all of the long-horned Spanish breed and of little value for their meat, except to the *saladero* establishments. Gradually Durham and Hereford stock were introduced to improve the native breeds, with results so satisfactory that now herds of three-quarters bred cattle are to be found in all parts of the country. Not only has the breed of cattle been improved, but the system of grazing has completely altered. Vast areas of land (probably 8,000,000 acres) have been ploughed and sown with lucerne, and magnificent permanent pasturage has been created where there were coarse and hard grasses in former days. In 1889 the first shipment of Argeotine cattle, consisting altogether of 1930 steers, was sent to England. The results of these first experiments were not encouraging, owing mainly to the poor class of animals, but the exporters persevered, and the business steadily grew in value and importance until in 1898 the number of live cattle shipped was 130,351. In 1899 the number fell to 103,568, of which 83,364 were shipped to England, 8290 to France, and 11,688 to Brazil. Large quantities of frozen meat were exported in 1899, profitable prices being realized. Dairy farming is making rapid strides, and the development of sheep-farming has been remarkable. In 1878, 65,000,000 sheep yielded 230,000,000 pounds' weight of wool, or an average per sheep of about 3½ pounds. In the season 1899-1900 the wool exports weighed 420,000,000 pounds, and averaged more than 5 pounds per sheep. The extra weight of fleece was owing to the very great improvement due to the large importation of rams from Europe and Australia. The export, moreover, of live sheep and of frozen mutton to Europe has become an important factor in the trade of Argeotina. In 1892 the number of live sheep shipped for foreign ports was 40,000; in 1898 the export reached a total of 619,378; and in 1899, 482,013. In 1892 the frozen mutton exported was 25,500 tons, and this had increased in 1898 to 29,778 tons.

The advance made in agricultural industry is also of very great importance. In 1872 the cultivated area was about 1,430,000 acres; in 1888, 6,074,000 acres; in 1895, 12,083,000 acres; in 1899, 16,055,000 acres. In 1899 the wheat exports exceeded 50,000,000 bushels, and the maize 40,000,000 bushels. The area under wheat in 1899 was 5,500,000 acres; maize, 6,000,000 acres; linseed, 200,000 acres. The farming industry is not, however, on a satisfactory basis. No national lands in accessible districts are available for the application of a homestead law, and the farmer too often has no interest in the land beyond the growing crops, a percentage of the harvest being the rent charged by the owner of the property. This system is mischievous, since, if a few consecutive bad seasons occur, the farmer moves to some more favoured spot. The principal wheat and maize-producing districts lie in the provinces of Santa Fé, Buenca Ayres, Cordova, and Entre Rios, and the average yield of wheat throughout the country in 1899 was, in round numbers, 12 bushels to the acre. Little attention is paid to methods of cultivation, and the farmer has no resources to help him if the cereal crops fail. In the Andean provinces of Mendoza, San Juan, Catamarca, and La Rioja viticulture is widely practised, and the area of the vineyards now exceeds 150,000 acres. Wine is manufactured in large quantities, but the output is not yet sufficient to meet the home demand. In the province of Tucuman the main industry is sugar-growing and manufacture. In 1899 the production of sugar was 110,000 tons, the total consumption of Argentina being estimated at 80,000 tons annually. The sugar manufacture, however, is a protected and bounty-fed industry. Other products are tobacco, olives, castor-oil, and fruit and vegetables for export to Brazilian markets.

The pastoral and agricultural industries have been hampered by fluctuations in the value of the currency, farm products being sold at a gold value for the equivalent in paper, while labourers are paid in currency. The existing system of taxation also presses heavily upon the provinces, as may be seen from the fact that the national, provincial, and municipal exactions together amount to £7 per head of population, while the total value of the exports in 1898 was only £8 in round numbers.

Manufactures.—Manufacturing enterprise in Argentina, in spite of the protection afforded by a high tariff, does not make any substantial progress. The reason put forward is the lack of coal or other available cheap fuel. At Cordova a central power station for the distribution of electricity obtained from water-power was erected in 1897; but so far very little use of this convenience has been made by factories. In Buenos Ayres several companies have established stations for distributing electric power generated by steam; but the cost is high, and the power has hitherto only been applied for lighting and for the electric tramways.

Commerce.—The rapid development of the foreign trade of the republic since 1881 is shown in the following table, the values of imports and exports being given in pounds sterling for the years named. In the period 1886-90 the trade was abnormally inflated, the average annual imports during the five years being of the value of £25,919,000, and of the exports £17,818,000.

Year.	Imports.	Exports.
	£	£
1881	11,100,000	11,580,000
1886	19,100,000	14,000,000
1891	18,442,000	20,644,000
1898	22,433,000	23,360,000
1898	21,486,000	26,766,000
1899	23,360,000	38,980,000
1900	22,897,000	30,920,000

The principal imports are textiles and raw materials, valued in 1900 at £7,519,570; iron and iron goods, £3,810,810; food stuffs, £2,090,670; glass and earthenware, £1,778,700. The values of the principal groups of exports were—pastoral products, £14,250,800; agricultural products, £15,485,200; forest products, £441,700; various, £701,800. Of the pastoral products the more important exports were—ox-hides, 3,359,460 in number; horse-hides, 120,100 in number; sheep-skins, 28,200 tons; wool, 112,105 tons; tallow, 353,880 cwts.; foreign wethers, 2,372,970 in number. The agricultural produce exported comprised 2,042,164 tons of wheat and 740,685 tons of maize. Of the imports in 1900, 34 per cent. in value come from the United Kingdom, 14 per cent. from Germany, 18 per cent. from Italy, 12 per cent. from the United States, and 9 per cent. from France. Of the exports 15 per cent. in value were shipped to the United Kingdom, 13 per cent. to Germany, 12 per cent. to France, and 11 per cent. to Belgium. More than half the foreign trade of the republic goes through the port of Buenos Ayres.

The commercial community has been passing through a most difficult period. Between 1880 and 1890 immense sums of European capital were invested in railways and other undertakings. The Mortgage Bank of the province of Buenos Ayres lent money recklessly in the form of *cedulas* nominally secured on landed property, credit was given far and wide, and the import trade rapidly developed. In 1890 a financial crisis came, credit contracted, the value of property depreciated, and imports decreased. The constant fluctuations in the value of the currency were also an adverse factor. But recent commercial statistics indicate that the volume of trade is once more increasing. Credit is now sounder than for several years, and shows signs of further improvement. Many of the larger retailers now import their wares direct from Europe, and thus save the intermediate commission charges. Present difficulties arise mainly from the appreciation of the currency and recent additions to taxation. In consequence of these two factors the expenses of a trading establishment are now, with a premium on gold of only 127 per cent., greater than they were when the premium stood at 300 per cent.

Shipping and Navigation.—The shipping under the Argentine flag in 1898 consisted of 1416 sailing ships of a total tonnage of 118,894 tons and 222 steamships of 36,323 tons. The shipping entered at Argentine ports in the foreign trade in 1891 had a total tonnage of 5,275,094; in 1896, 7,115,467; in 1897, 6,185,062; in 1898, 8,555,128; in 1899, 8,939,567.

Railways.—The rapid development of the railway system is indicated by the following figures, which show the length of line open in various years from 1880:—

Year.	Miles Open.	Year.	Miles Open.
1880	1,435	1895	8,887
1885	2,820	1898	9,885
1890	5,745	1899	10,285

The trans-Andean line is open to Santa Rosa, but 46 miles are required to unite the Argentine and Chilian sections.

In 1900 the capital invested in the railways amounted to £105,323,324, of which £10,991,750 corresponded with the state lines, and the remainder with the private lines. In the course of 1900 the railways carried 17,898,981 passengers and 12,719,297 tons of goods, the average working expenses of all the lines in operation being (1898) 62 per cent. of the gross receipts.

In consequence of the action of competing undertakings, the companies, without any National Government guarantee on the capital they employed, were compelled to extend their works, and expansion was only checked when the financial crisis of 1890 destroyed for a time the credit of Argentina in the money markets of Europe. The concessions granted during the tenure of office of President Roca from 1880 to 1886 had the specific object of uniting outlying districts with the capital, and could be justified on political as well as economic grounds. Those issued broadcast by President Celman had no such *raison d'être* and were simply political jobs, which brought the guaranteed railway system into disrepute.

Tramways.—In 1895 there were in operation 460 miles of tramways, 36 miles in construction and 32 miles projected. These lines had a capital of $84,000,000 paper, and in 1894 carried 88,306,866 passengers. In 1895 there were 179 stage-coach companies travelling over 11,940 miles of road.

Telegraphs.—In 1896 the Argentine Republic had 25,845 miles of telegraph lines and 1237 offices. The national telegraph lines had a length of 11,023 miles with 23,572 miles of wire; the railway lines, 7070 miles with 18,717 miles of wire; companies' lines, 4428 miles with 7462 miles of wire; other lines, 2824 miles with 9309 miles of wire. The despatches sent numbered 4,953,887.

Posts.—The Argentine Republic joined the Postal Union in 1878. In four years the national post offices handled mail pieces to the following numbers:—In 1894, 127,584,667 pieces; 1895, 142,438,240; 1896, 177,641,001; 1897, 190,506,860. In 1897 the internal correspondence amounted to 187,634,383 letters and papers, and the foreign to 22,872,487. In 1897 there were 1718 post offices. The revenue derived from the post offices, including the telegraphs, in 1897 was $15,257,966; the expenditures, $30,347,390.

Credit.—By law of 18th October 1891 the old National Bank was placed in liquidation, and the Banco de la Nacion Argentina was opened. Within the republic there are many other banks, both state and private. The National and Provincial Hypothecary Banks, in the spendthrift period between 1886 and 1890, exercised a disastrous influence on Argentine credit. The fundamental principle of these mortgage banks was sound enough, the idea being that the bonds issued (*cedulas*) should be a first charge on real estate of approved value, and that their face value should not represent more than 75 per cent. of the approved value of the property. But in the "boom" of 1887-89 *cedulas* were issued on the nominal value of property and through political influence, so that many millions of dollars were obtained on waste and worthless lands. When the true condition of affairs came to light it was found that *cedulas* amounting to some $400,000,000 had been issued by the Provincial Hypothecary Bank, and to about $120,000,000 by the National Bank. In the case of the Provincial Bank the security of the lands mortgaged was found to represent only about 10 per cent. of the nominal value of the *cedulas* issued. The guarantee of the Provincial Government had been attached to these bonds, but the province was in a bankrupt condition. Unfortunately, the *cedulas* had been largely bought in Europe under the impression that they were secured upon valuable real estate. When their price fell, nearly all landowners in possession of valuable properties and owing money to the bank at once bought up the bonds at depreciated values and cancelled their indebtedness. The bank was, therefore, left with only the mortgages that were worthless, and practically the $250,000,000 of *cedulas* now outstanding in Europe and Argentina are without intrinsic value. By careful management the affairs of the National Hypothecary Bank were brought to a fairly sound financial condition, but this was in great part owing to the fact that the charter of the bank practically confined all mortgages to the municipality of Buenos Ayres, where property has steadily risen in value for some years past.

The development of the resources of Argentina is effected largely by means of foreign capital. In a consular report of July 1900, the foreign capital invested in undertakings within the country is estimated at £122,865,000, of which £119,018,000 is for railways and tramways, and the interest annually paid to capitalists outside the republic is put at about £4,900,000.

The paper money in circulation on 31st December 1899 amounted to $291,328,000, or about £25,600,000, gold being at a premium of 127 per cent. On 4th November of that year a law was passed for the conversion of the paper currency into gold dollars at the rate of 44 cents gold per paper dollar, provision being made for the formation of a conversion fund. In April 1900 the fund amounted to $3,200,000 gold, or £640,000. It is anticipated that five years must elapse before the fund can reach an amount sufficient for an attempt to carry out the conversion.

The metric system has been nominally compulsory since 1887, but the old Argentine system is not yet abandoned.

AUTHORITIES.—ALSINA, JUAN A. *La Inmigración Europea en la Republica Argentina.* Buenos Ayres, 1898.—*Argentine-Chilian Boundary: Report presented to the British Arbitration Tribunal on behalf of the Argentine Government.* 4 vols. London, 1900.—CARRANZA, ARTURO B. *Constitución Nacional y Constituciones Provinciales Vigentes.* Buenos Ayres, 1898.—DAIREAUX, EMILE. *La Vie et les Mœurs à La Plata.* Paris, 1888.—DE GUBERNATIS, COMTE ANGELO. *L'Argentina.* Firenze, 1898.—GALARCE, A. *Bosquejo de Buenos Ayres, capital de la Nacion Argentina.* Buenos Ayres, 1886. 2 vols.—GONZALES, MELITON. *El Gran Chaco Argentino.* Buenos Ayres, 1890. — GRANT AND SONS, JOHN. *English Directory and Argentine Commercial Guide.* Buenos Ayres, 1899. —LATZINA, FRANCIS. *Diccionario Geografico Argentino.* Buenos Ayres, 1891.—*Géographie de la République Argentine.* Buenos Ayres, 1890. —*L'Agriculture et l'Elevage dans la République Argentine.* Paris, 1889.—MITRE, BARTOLOMÉ. *Historia de San Martin y de la Emancipacion Sud-Americana, Según nuevos documentos.* Buenos Ayres, 1887. 3 vols.—*Historia de Belgrano y de la Independencia Argentina.* Buenos Ayres, 1888. 3 vols.—MULHALL, M. G. and E. T. *Handbook of the River Plate.* London, 1892.—SCHMITZ, OTTO. *Die Finanzen Argentiniens.* Leipzig, 1895.—SOLDAN, FELIPE. *Diccionario Geografico Estadistico Nacional Argentino.* Buenos Ayres, 1885.—TURNER, THOS. A. *Argentina and the Argentines.* New York and London, 1892.—ZEBALLOS, ESTANISLAO S. *Descripcion Amena de la Republica Argentina.* Buenos Ayres, 1881. 3 vols.—*Anuario de la Direccion General de Estadistica 1898.* Buenos Ayres, 1899.—WIENER, CHARLES. *La République Argentine.* Paris, 1899.—*Segundo Censo Republica Argentina.* Buenos Ayres, 1895. 3 vols.—HILDER, F. F. *Education in the Argentine Republic.* Washington, 1899.—*Handbook of the Argentine Republic.* Bureau of the American Republics, Washington, 1892.—*United States Consular Reports.* Washington.—*British Foreign Office Diplomatic and Consular Reports.* London.

(W. W. R.; I. P. A. R.; C. E. A.)

II. RECENT HISTORY.

The history of Argentina since the time of its emancipation from Spain is a confused, wearisome story of political intrigues, party struggles, civil wars, and military revolutions. In 1875 the temporary lull led many people to believe that the period of civil strife was at an end and that no new revolutionary movements would be attempted for a long time to come. These sanguine expectations were not destined to be realized. During the presidency of Dr Avellaneda, who had succeeded Sarmiento in the office of chief magistrate, political feeling in the city and province of Buenos Ayres began to show unmistakable signs of forcing to an issue the question as to what position Buenos Ayres was to hold for the future in regard to the remaining provinces of the confederation. Before retiring from office, the President endeavoured to secure the election of General Julio Roca as his successor, and on this point hinged the principal political events of 1879, leading to the civil war of 1880, by which the power of Buenos Ayres was crushed. When, in 1879, the people of Buenos Ayres perceived that the decentralization party had determined to leave no stone unturned to secure the election of General Roca, and so make sure that the provinces became the dominant element in the political situation, an agitation was immediately set on foot. Mass meetings were held and a committee was appointed for the purpose of considering what action should be taken to defeat the ambitious designs of the provincials. Under the direction of this committee, the association known as the "Tiro Nacional" was formed, with the avowed object of training the able-bodied citizens of Buenos Ayres in military exercises and creating a volunteer army, ready for service, if called upon, to resist by force the pretensions of their opponents. The establishment of the Tiro Nacional was enthusiastically received by all classes in Buenos Ayres, the men turning out regularly to drill and the women aiding the movement by collecting subscriptions for the purpose of armament and other necessaries. On the 13th of February, 1880, the Minister of War, Dr Pellegrini, summoned the principal military officers connected with the Tiro Nacional, and warned them that as officers of the national army they owed obedience to the National Government and would be severely punished if concerned in any revolutionary outbreak directed against the constituted authorities. The reply to this threat was the immediate resignation from the army of all the officers connected with the Tiro Nacional. Two days later, the National Government occupied with a strong force of infantry and artillery the parade ground at Palermo used by the Buenos Ayres volunteers for drill purposes. A great meeting of the citizens was then called and marched through the streets. President Avellaneda, finding his position insecure, made a compromise and ordered the troops to be withdrawn. Negotiations were now opened between the National Government and the provincial authorities for the disarmament of the city and province of Buenos Ayres, but without result. Matters became still further strained on account of outrages committed by the national troops, and the gradual development of the situation brought about such violent bitterness of feeling between the two factions that an appeal to arms became inevitable.

In the month of March, 1880, President Avellaneda and his Ministers left Buenos Ayres, and this act was considered tantamount to a declaration of war. The National Government and the twelve provinces, forming the Cordova League, were on one side; the province and city of Buenos Ayres and the province of Corrientes on the other. The National Government troops were well armed with Remington rifles, provided with abundant ammunition, equipped with artillery, and supported by the fleet. In the city and province of Buenos Ayres plenty of volunteers offered their services, and an army of some 30,000 men was quickly raised, but they were armed with old-fashioned weapons and there was only a limited supply of ammunition. Feverish attempts were made to remedy the lack of warlike stores, but difficulty was experienced on account of the fleet blockading the entrance to the river. After several skirmishes, the contending armies met in force on the 20th of July, 1880, in the outskirts of Buenos Ayres, General Roca commanding the national troops. Two days' fighting took place, and the Buenos Ayres forces were finally outmatched at all points. On the 23rd of July the surrender of the city was demanded and obtained. The terms of the surrender were that all the principal men of the revolution should be removed from positions of authority, all Government *employés* implicated in the movement dismissed, and the forces in the province and city of Buenos Ayres at once disarmed and disbanded. The power of Buenos Ayres was thus completely broken and at the mercy of the Cordova League, represented by their favourite candidate for the presidency, General Julio Roca. Buenos Ayres was no longer in a position to take any active part in the nomination of a successor to President Avellaneda, and the official candidate, General Roca, was declared to be duly elected without opposition. He assumed office in October, 1880. Hitherto, General Roca had been regarded only in his capacity of a soldier, and not from the point of view of an administrator. In the campaign against the Indians in the south-west of the province of Buenos Ayres and the valley of the Rio Negro and the Neuquen district, he had gained much prestige; the victory over the forces at Buenos Ayres added to his fame, and secured his authority in the outlying provincial centres. One of the first most notable acts of the Roca Administration was to declare the city of Buenos Ayres the property of the National Government, and no longer under the control of the provincial authorities. Some compensation was granted to the province in consideration of this change, but nothing that was given could adequately represent the political loss which it suffered. A further blow was dealt at its supremacy in 1884, when the town of La Plata was declared to be the provincial capital, and the Provincial Government was moved to that place.

Considering the circumstances in which General Roca assumed office, it must be admitted that he showed great moderation, and that on the whole his administration was fairly successful. Public affairs were conducted quietly so far as the National Government was concerned, and the influence and prestige of Roca throughout the provinces acted as a deterrent to *pronunciamientos* and outbreaks against the provincial authorities. The danger of these internal dissensions was permanently lessened, though by no means entirely removed, by the extension of railways. Unfortunately, the last two years of Roca's administration were characterized by two grave errors, which subsequently caused widespread suffering and distress throughout the country. The first of these mistakes was a measure making the currency inconvertible, which was adopted without any consideration as to its effect on the national credit. The second was the nomination of Dr Miguel Juarez Celman for the presidential term commencing in October, 1886. The nomination was brought about by the Cordova clique, and Roca lacked the moral courage to oppose the decision of this group, though he was well aware that Celman, who was his brother-in-law, was neither intellectually nor morally fitted for the post. No sooner had President Juarez Celman come into power, towards the close of 1886, than the respectable portion of the community began to feel alarmed at the methods practised by the new president in his conduct of public affairs. At first it was hoped that the influence of General Roca would serve to check any serious extravagances on the part of Celman. This hope, however, was doomed to disappointment, and before many months had elapsed it was clear that the President would listen to no prudent counsels from Roca or any one else. The men of the old Cordova League became dominant in all branches of the Government, and carpet-bagging politicians occupied every official post. In their hurry to obtain wealth, this crowd of office-mongers from the provinces lent themselves to all kinds of bribery and corruption. The public credit was pledged at home and abroad to fill the pockets of the adventurers, and the wildest excesses were committed under the guise of administrative acts. What followed in the second and third years of the Celman Administration can only adequately be described as a debauchery of the national honour, of the national resources, of the rights of Argentines as citizens of the Republic. Buenos Ayres was still prostrate under the crushing blow of the misfortunes of 1880, and lacked the strength and power of organization necessary to raise any effective protest against the proceedings of Celman and his friends when the true character of these proceedings was first understood. The conduct of public affairs, however, at length became so scandalous that action on the part of the more sober-minded and more conservative sections was seen to be absolutely imperative if the country was to be saved from speedy and certain ruin. In 1889, the association of the "Union Civica" was founded, and the organization undertaken by Dr Leandro Alem, Dr Aristobulo del Valle, Dr Vicente Lopez, Dr Lucio Lopez, and other leading citizens. Mass meetings were held in Buenos Ayres, and Dr del Valle, a most able orator, clearly explained the terrible danger threatening the Republic in consequence of the irresponsible and corrupt character of the Administration. Subsidiary clubs affiliated to the central association were formed throughout the length and breadth of the country, and millions of leaflets and pamphlets were distributed broadcast to explain the importance of the movement. President Celman underrated the strength of the new opposition and relied upon his armed forces promptly to suppress any sign of open hostility. No change was made in official methods, and the condition of affairs drifted from bad to worse until the temper of the people, so long and so sorely tried, showed plainly that the situation had become insufferable. The Union Civica then decided to make a bold bid for freedom by attempting forcibly to eject Celman and his clique from office.

On the night of the 26th of July, 1890, the Union Civica called its members to arms. It was joined by some regiments of the regular army, and received the support of the fleet. Barricades were thrown up in the principal streets, and the surrounding houses were occupied by the insurgents. Two days of desultory street fighting ensued, during which the fleet began to bombard the city, but was compelled to desist by the interference of foreign men-of-war, on the ground that the bombardment was causing unnecessary damage to the life and property of non-combatants. A suspension of hostilities then took place and negotiations were opened between the contending parties. Celman, acting under the advice of General Roca, who recognized the strength of public opinion in the outbreak and foresaw a more powerful movement looming in the distance, placed his resignation in the hands of congress on the 31st of July. A scene of immense enthusiasm followed, and Buenos Ayres was *en fête* for the following three days. Vice-President Carlos Pellegrini succeeded to the office vacated by Juarez Celman and to the administrative confusion resulting from the iniquitous methods of conducting public affairs during the previous four years.

Great expectations were formed of the ability of President Pellegrini to establish a sound Administration and to introduce a system of government ensuring the peace and progress of the Republic. General Roca tendered his services for the duties of Minister of the Interior, and his influence in the provinces was of very great assistance to the national authorities. Dr Vicente Lopez undertook the post of Minister of Finance, an onerous task in view of the financial complications resulting from the previous reckless extravagance. In short, all the most respectable elements in the country showed willingness to co-operate in the restoration of a normal condition of affairs and the establishment of political order, but the result did not come up to public expectation. Pellegrini proved a failure. Of great natural intelligence, and with the advantages of a sound education at Harrow, combined with much charm of manner and widespread personal popularity, he showed himself during his term of office merely a politician, with no genuine statesmanlike qualities. The new Government made no attempt to initiate a strong policy of reform in administration or finance; it became a Government of expedients, drifting helplessly on a sea of financial troubles, and seeking merely to prevent serious political disturbances. This unsatisfactory state of affairs aroused the hostility of the Radical wing of the Union Civica, and Dr Alem preached far and wide the doctrine of opposition to the Government and the necessity of reform in the methods of administering the country. The more conservative section of the Union Civica refused to join in this opposition movement, and Dr Alem was arrested and exiled.

In 1892, Pellegrini's term of office expired and a successor had to be chosen. General Bartolome Mitre was proposed by the Buenos Ayres faction as their candidate. He had been absent from Argentina on a journey to Europe, and it was on his return in April, 1891, when a popular reception was given to him at which 50,000 persons attended, that he had formally accepted the candidacy for the presidential office. His partisans found themselves confronted by a compact provincial party who proposed to put forward General Roca, or, failing his acceptance, some other representative to oppose the Buenos Ayres candidate. There was no doubt that if both sides persisted in the struggle on the lines indicated a civil war must inevitably result. General Mitre disapproved of any measures likely to involve bloodshed and sought to effect a compromise. A meeting between him and General Roca resulted in an *acuerdo*, by which the two generals agreed to support a neutral candidate having no direct connexion with either of the political parties. The final selection for the candidacy fell upon Dr Saenz Peña, a Judge of the Supreme Court, and a man universally respected, who had never taken part in political life. In May, 1892, the presidential elections were held; Dr Saenz Peña was declared duly elected, and Señor Uriburu, then Argentine Minister in Chile, was chosen as Vice-President.

The idea of President Saenz Peña was to conduct the government on common-sense and business-like lines. He had no political training, no political party in Congress to support him; he was simply a straightforward, honourable man trying to do his duty in a position which had been forced upon him, and was in no sense of the word of his own seeking. No sooner was he installed in office than difficulties began to crop up on all sides, and he quickly discovered that no help could be expected from the two political factions which had brought him into power to suit their own convenience. To govern without a majority in Congress was a practical impossibility, and before twelve months of the presidential term had run public affairs had drifted to a deadlock. This was the opportunity of Dr Alem, the Radical leader of the Union Civica, and he was not slow to profit by the occasion. Embittered by his treatment in 1892, he openly preached the advisability of an armed rising and the overthrow of the existing Administration. The unscrupulous acts of corruption on the part of Dr Julio Costa, then Governor of the province of Buenos Ayres, strengthened the movement. A number of officers of the naval and military forces agreed to lend assistance to the revolutionary outbreak, and towards the end of July, 1893, matters came to a head. The population of the province of Buenos Ayres assembled in armed bodies with the avowed intention of turning the Governor out of office and electing in his stead a man who would give them a just Administration. At the commencement of the movement, Governor Costa imagined himself strong enough to hold his own with the aid of his police and several battalions of provincial troops quartered at La Plata; but as the insurrection spread he appealed for aid to the National Government. President Saenz Peña professed to doubt his authority to interfere in provincial affairs, and deliberated for many days before he took action in the matter. Eventually, the intervention of the National Government was decided upon, and troops were despatched to the scene of the disturbance; but there was no serious fighting. Negotiations were soon opened, and resulted in the resignation of Governor Costa and the dispersal of the armed insurrectionary forces.

While these political disturbances were in progress in Buenos Ayres, another revolutionary rising took place in the province of Santa Fé. Dr Alem, preaching his gospel of a reform of the national Administration, induced a number of his co-religionists of the Union Civica to take up arms. Several military and naval officers joined the movement, and a gunboat and one or two torpedo boats were seized by the insurgents. The scene of the insurrection was the vicinity of Rosario, and this city was in possession of the insurgents for a few days. After a few skirmishes, the revolt was suppressed by the national authorities in September, 1893, and Dr Alem and the other conspirators were captured. He and his civilian friends were sentenced to banishment to Staten Island during the pleasure of the Federal Government, and were immediately transported to that isolated spot. Of the naval and military officers, some were condemned to be shot and the others to serve various terms of imprisonment. This severity on the part of the Court-martial brought about fresh troubles. President Saenz Peña was determined that the sentences should be carried out. Congress was equally decided that the death penalty should not be inflicted. The Ministry at first supported the President in a half-hearted manner and then deserted him as the opposition in the Chambers gathered strength. The struggle between Congress and the Executive continued for some weeks, the former refusing to vote the Budget or any supplies unless the President conformed to the desires of the Chambers in the matter of the officers implicated in the Santa Fé outbreak. On the 21st of January, 1895, the President found his position no longer tenable, and preferred to resign rather than act against his convictions. That the government of Dr Saenz Peña was weak and vacillating is not to be gainsaid; but he himself was honest in his intention of doing his duty in the trust confided to him, and the chief cause of his unpopularity was probably the fact that he belonged to no distinct political party and consequently commanded no following among the members of Congress. His resignation was at once accepted by the Chambers, and the Vice-President, Dr Uriburu, became President of the Republic for the remainder of the period of six years for which Dr Saenz Peña had been elected in 1892.

President Uriburu was neither a politician nor a statesman; he had spent the greater portion of his life abroad in the Argentine diplomatic service, and could count on no political following in his own country. It was, indeed, on account of his belonging to no political party that he had been elected Vice-President. During his term of office the boundary question with Chile was the subject which chiefly attracted public attention. Internal politics were dwarfed in comparison with this important issue. The strain on both Governments was extremely severe. On both sides, from time to time, the populace clamoured for an appeal to arms. The resources of both countries were squandered in military preparations, and the National Guards were called out and constantly drilled in order to be ready in case of an emergency. In August, 1898, matters reached a climax. The choice lay between war and arbitration. The tendency of both nations was to decide the dispute by force of arms, but wiser counsels finally prevailed and arbitration was agreed upon. The question of the Puña of Atacama was referred to a tribunal composed of the United States Minister to Argentina, one Argentine and one Chilian delegate; that of the southern territory in Patagonia was referred to the British Crown. The decision of the representative of the United States was given in April, 1899. Although the Chilians professed to be dissatisfied with the award, no active opposition was raised and the terms were duly notified. Up to the end of 1901 the decision of the Arbitration Commission appointed by the British Government had not been given. Further details regarding certain points were required, and, in order to obtain these, Argentine and Chilian expeditions were sent to Patagonia. In view of the occupation of Ultima Esperanza, part of the disputed territory, by Argentine colonists, the Governments of Chile and Argentina signed a protocol on 27th December agreeing to take no aggressive action, and to instruct the local authorities to maintain the previous position. No other boundary disputes can now arise, as the question with Brazil was settled by the award of President Cleveland in 1894, and subsequently accepted and ratified by the Argentine and Brazilian Governments.

In 1898 there was again a presidential election. Public opinion, excited by the prospect of a war with Chile, naturally supported the candidature of General Roca, and he was elected without opposition (12th October, 1898). Before he had been many weeks in office he arranged to meet the President of the Chilian Republic in the Strait of Magellan, and held a conference with him which confirmed the amicable solution of the frontier question. In his Message to Congress on the 1st of May, 1899, General Roca spoke strongly of the immediate necessity of a reform in the methods of administering justice, the expediency of a revision of the electoral law, and the imperative need of a reconstruction of the Department of Public Instruction. Justice, he said, had come to so low a level as to be practically non-existent. Of the necessity of electoral reform the following may serve as an illustration:—In March, 1899, elections were held for Deputies for the Provincial Chamber of Buenos Ayres, and resulted in the return of a substantial majority opposed to the Governor. They were at once annulled, and at the new elections the supporters of the Governor had a decided majority. On 31st August of the same year, President Roca sent to Congress a series of proposals for dealing with the currency question and certain branches of finance connected with the national revenue and expenditure. The scheme included the conversion of the currency at the rate of 44 cents gold for each paper dollar. The President declared that he was determined to make every effort to reduce the national expenditure, adding that the object of fixing the rate of the relation of gold to currency was to do away with the violent fluctuations in the value of the paper dollar, which caused so much damage to commerce and all classes of industry. In spite of the adverse feeling which prevailed in many quarters, the Conversion Bills were passed by the Senate and the Chamber of Deputies, and became law on 6th November.

In 1900 considerable anxiety was caused in Argentina by what was regarded as the aggressive attitude of Chile towards Bolivia. Dr Campos Salles, the President of Brazil, paid a visit to Buenos Ayres in October and was very warmly received. The result of the conversations between the two Presidents was an understanding that instructions should be sent to all Argentine and Brazilian representatives abroad to lose no opportunity to advocate the maintenance of peace in South America, and to discountenance the idea of any South American Government acquiring an extension of territory by force of arms.

The city and province of Buenos Ayres have been rapidly recovering by natural causes the political predominance which they lost in 1880. Representation in the Argentine Congress is accorded to the various provinces in proportion to their population. Until 1895 the number of seats in the Chamber of Deputies was based upon the census of 1869, which gave the provinces a large majority over the city and province of Buenos Ayres. Under the census of 1895 the increase of population in Buenos Ayres entitled the capital and province to a greater number of seats, and no fewer than 47 members for city and province together are returned out of the total number of 116 for the whole Republic.

The chief political question agitating the people of Argentina is that of heavy protective duties as against a moderate tariff—practically, protection *versus* free trade. The farmers of all classes, agricultural and pastoral, demand a reduction of the tariff; while the manufacturers of sugar and other articles, which thrive only in consequence of the prohibitive duties, use all their political influence to maintain the existing system.

(C. E. A.)

Argenton, a town of France, in the arrondissement of Châteauroux, department of Indre, on the R. Creuse, 18 miles S.S.W. of Châteauroux on the railway to Le Blanc. Excellent wine is produced; tanning, the manufacture of boots and shoes, and linen goods, are leading industries. The actual site of the ancient *Argentomagus* lies a little to the north, and is occupied by ST MARCEL. Population (1881), 5167; (1891), 5503; (1901), 6281, (comm.) 5978.

Argon.—For more than a hundred years before 1894 it had been supposed that the composition of the atmosphere was thoroughly known. Beyond variable quantities of moisture and traces of carbonic acid, hydrogen, ammonia, &c., the only constituents recognized were nitrogen and oxygen. The analysis of air was conducted by determining the amount of oxygen present and assuming the remainder to be nitrogen. Since the time of Cavendish no one seemed even to have asked the question whether the residue was, in truth, all capable of conversion into nitric acid.

The manner in which this condition of complacent ignorance came to be disturbed, is instructive. Observations undertaken mainly in the interest of Prout's law, and extending over many years, had been conducted to determine afresh the densities of the principal gases—hydrogen, oxygen, and nitrogen. In the latter case, the first preparations were according to the convenient method devised by Vernon Harcourt, in which air charged with ammonia is passed over red-hot copper. Under the influence of the heat the atmospheric oxygen unites with the hydrogen of the ammonia, and when the excess of the latter is removed with sulphuric acid, the gas properly desiccated should be pure nitrogen, derived in part from the ammonia, but principally from the air. A few concordant determinations of density having been effected, the question was at first regarded as disposed of, until the thought occurred that it might be desirable to try also the more usual method of preparation in which the oxygen is removed by actual oxidation of copper without the aid of ammonia. Determinations made thus were equally concordant among themselves, but the resulting density was about $\frac{1}{1000}$ part greater than that found by Harcourt's method (Rayleigh, *Nature*, vol. xlvi. p. 512, 1892). Subsequently when *oxygen* was substituted for air in the first method, so that all (instead of about one-seventh part) of the nitrogen was derived from ammonia, the difference rose to one-half per cent. Further experiment only brought out more clearly the diversity of the gases hitherto assumed to be identical. Whatever were the means employed to rid air of accompanying oxygen, a uniform value of the density was arrived at, and this value was one-half per cent. greater than that appertaining to nitrogen extracted from compounds such as nitrous oxide, ammonia, and ammonium nitrite. No impurity, consisting of any known substance, could be discovered capable of explaining an excessive weight in the one case, or a deficiency in the other. Storage for eight months did not disturb the density of the chemically extracted gas, nor had the silent electric discharge any influence upon either quality. ("On an Anomaly encountered in determining the Density of Nitrogen Gas," *Proc. Roy. Soc.*, April 1894.)

At this stage it became clear that the complication depended upon some hitherto unknown body, and probability inclined to the existence of a gas in the atmosphere heavier than nitrogen, and remaining unacted upon during the removal of the oxygen—a conclusion afterwards fully established by Rayleigh and Ramsay. The question which now pressed was as to the character of the evidence for the universally accepted view that the so-called nitrogen of the atmosphere was all of one kind, that the nitrogen of the air was the same as the nitrogen of nitre. Reference to Cavendish showed that he had already raised this question in the most distinct manner, and indeed, to a certain extent, resolved it. In his memoir of 1788 he writes:—

> As far as the experiments hitherto published extend, we scarcely know more of the phlogisticated part of our atmosphere than that it is not diminished by lime-water, caustic alkalies, or nitrous air; that it is unfit to support fire or maintain life in animals; and that its specific gravity is not much less than that of common air; so that, though the nitrous acid, by being united to phlogiston, is converted into air possessed of these properties, and consequently, though it was reasonable to suppose, that part at least of the phlogisticated air of the atmosphere consists of this acid united to phlogiston, yet it may fairly be doubted whether the whole is of this kind, or whether there are not in reality many different substances confounded together by us under the name of phlogisticated air. I therefore made an experiment to determine whether the whole of a given portion of the phlogisticated air of the atmosphere could be reduced to nitrous acid, or whether there was not a part of a different nature to the rest which would refuse to undergo that change. The foregoing experiments indeed, in some measure, decided this point, as much the greatest part of air let up into the tube lost its elasticity; yet, as some remained unabsorbed, it did not appear for certain whether that was of the same nature as the rest or not. For this purpose I diminished a similar mixture of dephlogisticated [oxygen] and common air, in the same manner as before [by sparks over alkali], till it was reduced to a small part of its original bulk. I then, in order to decompound as much as I could of the phlogisticated air [nitrogen] which remained in the tube, added some dephlogisticated air to it and continued the spark until no further diminution took place. Having by these means condensed as much as I could of the phlogisticated air, I let up some solution of liver of sulphur to absorb the dephlogisticated air; after which only a small bubble of air remained unabsorbed, which certainly was not more than $\frac{1}{120}$ of the bulk of the dephlogisticated air let up into the tube; so that, if there be any part of the dephlogisticated air of our atmosphere which differs from the rest, and cannot be reduced to nitrous acid, we may safely conclude that it is not more than $\frac{1}{120}$ part of the whole.

Although, as was natural, Cavendish was satisfied with his result, and does not decide whether the small residue was genuine, it is probable that his residue was really of a different kind from the main bulk of the "phlogisticated air," and contained the gas afterwards named Argon.

The announcement to the British Association in 1894 by Rayleigh and Ramsay of a new gas in the atmosphere was received with a good deal of scepticism. Some doubted the discovery of a new gas altogether, while others denied that it was present in the atmosphere. Yet there was nothing inconsistent with any previously ascertained fact in the asserted presence of 1 per cent. of a non-oxidizable gas about half as heavy again as nitrogen. The nearest approach to a difficulty lay in the behaviour of liquid air, from which it was supposed, as the event proved erroneously, that such a constituent would separate itself in the solid form. The evidence of the existence of a new gas (named Argon on account of its chemical inertness), and a statement of many of its properties, were communicated to the Royal Society (see *Phil. Trans.* clxxxvi. p. 187) by the discoverers in January 1895. The isolation of the new substance by removal of nitrogen from air was effected by two distinct methods. Of these the first is merely a development of that of Cavendish. The gases were contained in a test-tube A (Fig. 1) standing over a large quantity of weak alkali B, and the current was conveyed in wires insulated by U-shaped glass tubes CC passing through the liquid and round the mouth of the test-tube. The inner platinum ends DD of the wire may be sealed into the glass insulating tubes, but reliance should not be placed upon these sealings. In order to secure tightness in spite of cracks, mercury was placed in the bends. With a battery of five Grove cells and a Ruhmkorff coil of medium size, a somewhat short spark, or arc, of about 5 mm. was found to be more favourable than a longer one. When the mixed gases were in the right proportion, the rate of absorption was about 30 c.c. per hour, about thirty times as fast as Cavendish could work with the electrical machine of his day. Where it is available, an alternating electric current is much superior to a battery and break. This combination, introduced by Spottiswoode, allows the absorption in the apparatus of Fig. 1 to be raised to about 80 c.c. per hour, and the method is very convenient for the purification of small quantities of Argon and for determinations of the amount present in various samples of gas, *e.g.*, in the gases expelled from solution in water. A convenient adjunct to this apparatus is a small voltameter, with the aid of which oxygen or hydrogen can be introduced at pleasure. The gradual elimination of the nitrogen is tested at a moment's notice with a miniature spectroscope. For this purpose a small Leyden jar is connected as usual to the secondary terminals, and if necessary the force of the discharge is moderated by the insertion of resistance in the primary circuit. When with a fairly wide slit the yellow line is no longer visible, the residual nitrogen may be considered to have fallen below 2 or 3 per cent. During this stage the oxygen should be in considerable excess. When the yellow line of nitrogen has disappeared, and no further contraction seems to be in progress, the oxygen may be removed by cautious introduction of hydrogen. The spectrum may now be further examined with a more powerful instrument. The most conspicuous group in the Argon spectrum at atmospheric pressure is that first recorded by Schuster (Fig. 2). Water vapour and excess of oxygen in moderation do not interfere seriously with its visibility. It is of interest to note that the Argon spectrum may be fully developed by operating upon a miniature scale, starting with only 5 c.c. of air (*Phil. Mag.* vol. i. p. 103, 1901).

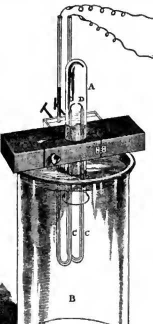


Fig. 1.

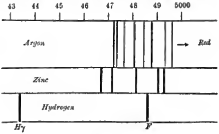


Fig. 2.

The development of Cavendish's method upon a large scale involves arrangements different from what would at first be expected. The transformer working from a public supply should give about 6000 volts on open circuit, although when the electric flame is established the voltage on the platinums is only from 1600 to 2000. No sufficient advantage is attained by raising the pressure of the gases above atmosphere, but a capacious vessel is necessary. This may consist of a glass sphere of 50 litres' capacity, into the neck of which, presented downwards, the necessary tubes are fitted. The whole of the interior surface is washed with a fountain of alkali, kept in circulation by means of a small centrifugal pump. In this apparatus, and with about one horse-power utilized at the transformer, the absorption of gas is 21 litres per hour ("The Oxidation of Nitrogen Gas," *Trans. Chem. Soc.*, 1897).

In one experiment, specially undertaken for the sake of measurement, the total air employed was 9250 c.c., and the oxygen consumed, manipulated with the aid of partially de-aërated water, amounted to 10,820 c.c. The oxygen contained in the air would be 1942 c.c.; so that the quantities of atmospheric nitrogen and of total oxygen which enter into combination would be 7308 c.c. and 12,762 c.c. respectively. This corresponds to $N + 1{\cdot}75\ O$, the oxygen being decidedly in excess of the proportion required to form nitrous acid. The Argon ultimately found was 75·0 c.c., or a little more than 1 per cent. of the atmospheric nitrogen used. A subsequent determination over mercury by Kellas (*Proc. Roy. Soc.* lix. p. 66, 1895) gave 1·186 c.c. as the amount of Argon present in 100 c.c. of mixed atmospheric nitrogen and Argon. In the earlier stages of the inquiry, when it was important to meet the doubts which had been expressed as to the presence of the new gas in the atmosphere, blank experiments were executed in which air was replaced by nitrogen from ammonium nitrite. The residual Argon, derived doubtless from the water used to manipulate the gases, was but a small fraction of what would have been obtained from a corresponding quantity of air.

The other method by which nitrogen may be absorbed on a considerable scale is by the aid of magnesium. The metal in the form of thin turnings is charged into hard glass or iron tubes heated to a full red in a combustion furnace. Into this air, previously deprived of oxygen by red-hot copper and thoroughly dried, is led in a continuous stream. At this temperature the nitrogen combines with the magnesium, and thus the Argon is concentrated. A still more potent absorption is afforded by calcium, prepared *in situ* by heating a mixture of magnesium dust with thoroughly dehydrated quick-lime. The density of Argon, prepared and purified by magnesium, was found by Professor Ramsay to be 19·941 on the O = 16 scale. The volume actually weighed was 163 c.c. Subsequently large-scale operations with the same apparatus as had been used for the principal gases gave an almost identical result (19·940) for Argon prepared with oxygen.

Argon is soluble in water at 12° C. to about 4·0 per cent., that is, it is about 2½ times more soluble than nitrogen. We should thus expect to find it in increased proportion in the dissolved gases of rain-water. Experiment has confirmed this anticipation. The weight of a mixture of Argon and nitrogen prepared from the dissolved gases showed an excess of 24 mg. over the weight of true nitrogen, the corresponding excess for the atmospheric mixture being only 11 mg. Argon is contained in the gases liberated by many thermal springs, but not in special quantity. The gas collected from the King's Spring at Bath gave only one-half per cent., *i.e.*, half the atmospheric proportion.

The most remarkable physical property of Argon relates to the constant known as the ratio of specific heats. When a gas is warmed one degree, the heat which must be supplied depends upon whether the operation is conducted at a constant volume or at a constant pressure, being greater in the latter case. The ratio of specific heats of the principal gases is 1·4, which, according to the kinetic theory, is an indication that an important fraction of the energy absorbed is devoted to rotation or vibration. If, as for Boscovitch points, the whole energy is translatory, the ratio of specific heats must be 1·67. This is precisely the number found from the velocity of sound in Argon as determined by Kundt's method, and it leaves no room for any sensible energy of rotatory or vibrational motion. The same value had previously been found for mercury vapour by Kundt and Warburg, and had been regarded as confirmatory of the monatomic character attributed on chemical grounds to the mercury molecule. It may be added that helium has the same character as Argon in respect of specific heats (Ramsay, *Proc. Roy. Soc.* l. p. 86, 1895).

The refractivity of Argon is ·961 of that of air. This low refractivity is noteworthy as strongly antagonistic to the view at one time favoured by eminent chemists that Argon was a condensed form of nitrogen represented by N_3. The viscosity of Argon is 1·21, referred to air, some-besides helium, to which have been assigned the names of Neon, Krypton, and Xenon. These gases agree with Argon in respect of the ratio of the specific heats and in being non-oxidizable under the electric spark. As originally defined, Argon included small proportions of these gases, but it is now preferable to limit the name to the principal constituent and to regard the newer gases as "companions of Argon." The physical constants associated with the name will scarcely be changed, since the proportion of the "companions" is so small. Professor Ramsay considers that probably the volume of all of them taken together does not exceed $\frac{1}{100}$th part of that of the Argon. The latest information with respect to the physical properties of these gases is conveyed in the following table (*Proc. Roy. Soc.* 67, p. 331, 1900):—

	Helium.	Neon.	Argon.	Krypton.	Xenon.
Refractivities (air = 1)	·1238	·2345	·968	1·449	2·364
Densities (O = 16)	1·98	9·97	19·96	40·88	64
Boiling points at 760 mm.	1	?	86·9° abs.	121·33° abs.	163·9° abs.
Critical temperatures	1	below 65° abs.	155·6° abs.	210·5° abs.	287·7° abs.
Critical pressures	?	?	40·2 metres.	41·24 metres.	43·5 metres.
Weight of 1 c.c of liquid	?	?	1·212 gm.	2·155 gm.	3·52 gm.

The glow obtained in vacuum tubes is highly characteristic, whether as seen directly or as analysed by the spectroscope. (R.)

Argos.—Recent investigation has added considerably to our knowledge concerning the Argive Heræum or Heraion, the temple of Hera, which stood, according to Pausanias, "on one of the lower slopes of Eubœa." The term Eubœa did not designate the eminence upon which the Heræum is placed, or the mountain-top behind the Heræum only, but, as Pausanias distinctly indicates, the group of foothills of the hilly district adjoining the mountain. When once we admit that this designated not only the mountain, which is 532 metres high, but also the hilly district adjoining it, the general scale of distance for this site grows larger. The territory of the Heræum was divided into three parts, namely Eubœa, Akraia, and Prosymna. Pausanias tells us that the Heræum is 15 stadia from Mycenæ. Strabo, on the other hand, says that the Heræum was 40 stadia from Argos and 10 from Mycenæ. Both authors underestimate the distance from Mycenæ, which is about 25 stadia, or a little more than 3 miles, while the distance from Argos is 45 stadia, or a little more than 5 miles. The distance from the Heræum to the ancient Midea is slightly greater than to Mycenæ, while that from the Heræum to Tiryns is about 6 miles. The Argive Heræum was the most important centre of Hera and Juno worship in the ancient world; it always remained the chief sanctuary of the Argive district, and was in all probability the earliest site of civilized life in the country inhabited by the Argive people. In fact, whereas the site of Hissarlik, the ancient Troy, is not in Greece proper, but in Asia Minor, and can thus not furnish the most direct evidence for the earliest Hellenic civilization as such; and whereas Tiryns, Mycenæ, and the city of Argos, each represent only one definite period in the successive stages of civilization, the Argive Heræum, holding the central site of early civilization in Greece proper, not only retained its importance during the three periods marked by the supremacy of Tiryns, Mycenæ, and the city of Argos, but in all probability antedated them as a centre of civilized Argive life. These conditions alone account for the extreme archæological importance of this ancient sanctuary.

According to tradition the Heræum was founded by Phoroneus at least thirteen generations before Agamemnon and the Achæans ruled. It is highly probable that before it became important merely as a temple, it was the fortified centre uniting the Argive people dwelling in the plain, the citadel which was superseded in this function by Tiryns. There is ample evidence to show that it was the chief sanctuary during the Tirynthian period. When Mycenæ was built under the Perseides it was still the chief sanctuary for that centre, which superseded Tiryns in its dominance over the district, and which this temple clearly antedated in construction. According to the *Dictis Cretensis*, it was at this Heræum that Agamemnon assembled the leaders before setting out for Troy. In the period of Dorian supremacy, in spite of the new cults which were introduced by these people, the Heræum maintained its supreme importance: it was here that the tablets recording the succession of priestesses were kept which served as a chronological standard for the Argive people, and even far beyond their borders; and it was here that Pheidon deposited the *obeliskoi* when he introduced coinage into Greece.

We learn from Strabo that the Heræum was the joint sanctuary for Mycenæ and Argos. But in the 5th century the city of Argos vanquished the Mycenæans, and from that time onwards the city of Argos becomes the political centre of the district, while the Heræum remains the religious centre. And when in the year 423 B.C., through the negligence of the priestess Chryseis, the old temple was burnt down, the Argives erected a splendid new temple, built by Eupolemos, in which was placed the great gold and ivory statue of Hera, by the sculptor Polycleitus, the contemporary and rival of Phidias, which was one of the most perfect works of sculpture in antiquity. Pausanias describes the temple and its contents (ii. 17), and in his time he still saw the ruins of the older burnt temple above the temple of Eupolemos.

All these facts have been verified and illustrated by the excavations of the American Archæological Institute and School of Athens, which were carried on from 1892 to 1895. In 1854 Rhangabé made tentative excavations on this site, digging a trench along the north and east sides of the second temple. Of these excavations no trace was to be seen when those of 1892 were begun. The excavations have shown that the sanctuary, instead of consisting of but one temple with the ruins of the older one above it, contained at least eleven separate buildings, occupying an area of about 300 metres by 100 metres.

On the uppermost terrace, defined by the great Cyclopean supporting wall, exactly as described by Pausanias, the excavations revealed a layer of ashes and charred wood, below which were found numerous objects of earliest date, together with some remains of the walls resting on a polygonal platform—all forming part of the earliest temple. Immediately adjoining the Cyclopean wall and below it were found traces of small houses of the rudest, earliest masonry which are pre-Mycenæan, if not pre-Cyclopean.

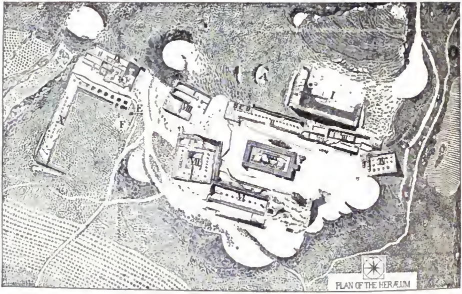
We then descend to the second terrace, in the centre of which the substructure of the great second temple was revealed, together with so much of the walls, as well as the several architectural members forming the superstructure, that it will be possible for the architects to design a complete restoration of the temple. On the northern side of this terrace, between the second temple and the Cyclopean supporting wall, a long stoa or colonnade runs from east to west abutting at the west end in structures which evidently contained a well-house and waterworks; while at the eastern end of this stoa a number of chambers were erected against the hill, in front of which were placed statues and inscriptions, the bases for which are still extant. At the easternmost end of this second terrace a large hall with three rows of columns in the interior, with a porch and entrance at the west end facing the temple, is built upon elaborate supporting walls of good masonry.

Below the second terrace at the south-west end a large and complicated building, with an open courtyard surrounded on three sides by a colonnade and with chambers opening out towards the north, may have served as a gymnasium or a sanatorium. It is of good early Greek architecture, earlier than the second temple. A curious, ruder building to the north of this and to the west of the second terrace is probably of much earlier date, perhaps of the Mycenæan period, and may have served as propylæa.

Immediately below the second temple, at the foot of the elevation on which this temple stands, towards the south, and thus facing the city of Argos, a splendid stoa or colonnade, to which large flights of steps lead, was erected about the time of the building of the second temple. It is a part of the great plan to give worthy access to the temple from the city of Argos. To the east of this large flights of steps lead up to the temple proper.

At the western extremity of the whole site, immediately beside the river bed, we again have a huge stoa running round two sides of a square, which was no doubt connected with the functions of this sanctuary as a health resort, especially for women, the goddess Hera presiding over and protecting married life and childbirth. Finally, immediately to the north of this western stoa there is an extensive house of Roman times also connected with baths.

While the buildings give archæological evidence for every period of Greek life and history from the pre-Mycenæan period down to Roman times, the topography itself shows that the Heræum must have been constructed before Mycenæ and without any regard to it. The foothills which it occupies form the western boundary to the Argive plain as it stretches down towards the sea in the Gulf of Nauplia. While it was thus probably chosen as the earliest site for a citadel facing the sea, its further relation points towards Tiryns and Midea. It could not have been built as the sanctuary of Mycenæ, which was placed farther up towards the north-west in the hills, and could not be seen from the Heræum, its inhabitants again not being able to see their sanctuary. The west building, the traces of bridges and roads, show that at one time it did hold some relation to Mycenæ; but this was long after its foundation or the building of the huge Cyclopean supporting wall which is coeval with the walls of Tiryns, these again being earlier than those of Mycenæ. There are, moreover, traces of still more primitive walls, built of rude small stones placed one upon the other without mortar, which are in character earlier than those of Tiryns, and have their parallel in the lowest layers of Hissarlik.



Plan of the Heræum (*surveyed and drawn by Edward L. Tilton*).
I, Old Temple; II, Stoa; III, Stoa; IV, East Building; V, 5th-Century Temple; VI, South Stoa; VII, West Building; VIII, North-West Building; IX, Roman Building; X, Lower Stoa; XI, Phylakeion; A, B, C, D, E, F, Cisterns.

Bearing out the evidence of tradition as well as architecture, the numerous finds of individual objects in terra-cotta figurines, vases, bronzes, engraved stones, &c., point to organized civilized life on this site many generations before Mycenæ was built, *à fortiori* before the life as depicted by Homer flourished—nay, before, as tradition has it, under Prœtus the walls of Tiryns were erected. We are aided in forming some estimate of the chronological sequence preceding the Mycenæan age, as suggested by the finds of the Heræum, in the new distribution which Dörpfeld has been led to make of the chronological stratification of Hissarlik in his most recent excavations of that site. For the layer, which he now assigns to the Mycenæan period, is the sixth stratum from below. Now, as some of the remains at the Heræum correspond to the two lowest layers of Hissarlik, the evidence of the Argive temple leads us far beyond the date assigned to the Mycenæan age, and at least into the second millennium B.C. (see also Mycenæan Civilization).

This sanctuary still holds a position of central importance as illustrating the art of the highest period in Greek history, namely, the art of the 5th century B.C. under the great sculptor Polycleitus. Though the excavations in the second temple have clearly revealed the outlines of the base upon which the great gold and ivory statue of Hera stood, it is needless to say that no trace of the statue itself has been found. From Pausanias we learn that "the image of Hera is seated and is of colossal size: it is made of gold and ivory, and is the work of Polycleitus." Based on the computations made by the architect of the American excavations, Mr Tilton, on the ground of the height of the nave, the total height of the image, including the base and the top of the throne, would be about 8 metres, the seated figure of the goddess herself about 5·50 metres.

It is probable that the face, neck, arms, and feet were of ivory, while the rest of the figure was draped in gold. Like the Olympian Zeus of Phidias, Hera was seated on an elaborately decorated throne, holding in her left hand the sceptre, surmounted in her case by the cuckoo (as that of Zeus had an eagle), and in her right, instead of an elaborate figure of Victory (such as the Athene Parthenos and the Olympian Zeus held), simply a pomegranate. The crown was adorned with figures of Graces and the Seasons. A Roman imperial coin of Antoninus Pius shows us on a reduced scale the general composition of the figure; while Antoninus Argive coins of the 5th century give a fairly adequate rendering of the head. A further attempt has been made to identify the head in a beautiful marble bust in the British Museum hitherto known as Bacchus (Waldstein, *Journal of Hellenic Studies*, vol. xxi. 1901, pp. 30 *seq.*).

We also learn from Pausanias that the temple was decorated with "sculptures over the columns, representing some the birth of Zeus and the battle of the gods and giants, others the Trojan war and the taking of Ilium." It was formerly supposed that the phrase "over the columns" pointed to the existence of sculptured metopes, but no pedimental groups. Finds made in the excavations, however, have shown that the temple also had pedimental groups. Besides numerous fragments of nude and draped figures belonging to pedimental statues, a well-preserved and very beautiful head of a female divinity, probably Hera, as well as a draped female torso of excellent workmanship, both belonging to the pediments, have been discovered. Of the metopes also a great number of fragments have been found, together with two almost complete metopes, the one containing the torso of a nude warrior in perfect preservation, as well as ten well-preserved heads. These statues bear the same relation to the sculptor Polycleitus which the Parthenon marbles hold to Phidias; and the excavations have thus yielded most important material for the illustration of the Argive art of Polycleitus in the 5th century B.C.

See the official publication of the *Excavations of the Argive Heræum*; WALDSTEIN. *Excavations of the American School of Athens at the Heraion of Argos*, 1892; and numerous reports and articles in the *American Archæological Journal* since 1892.

(C. W.*)

Argostoli. See GREECE (IONIAN ISLANDS).

Argyll, George John Douglas Campbell, 8TH DUKE OF (1823-1900), British statesman, was born 30th April 1823, and succeeded his father, the 7th duke, in April 1847. He had then already obtained notice as a writer of pamphlets on the disruption of the Church of Scotland, which he strove to avert, and he rapidly became prominent on the Liberal side in Parliamentary politics. He was a frequent and eloquent speaker in the House of Lords, and sat as Lord Privy Seal (1852) and Postmaster-General (1855) in the Cabinets of Lord Aberdeen and Lord Palmerston. In Mr Gladstone's Cabinet of 1868 he was Secretary of State for India, and infelicitously signalized his term of office by his refusal, against the advice of the Indian Government, to promise the Ameer of Afghanistan support against Russian aggression, a course which threw that ruler into the arms of Russia and was followed by the second Afghan war. With all the duke's activity and disposition to assert himself, this seems the only memorable political act recorded of him, except his resignation of the office of Lord Privy Seal, which he held in Mr Gladstone's Administration of 1880, from his inability to assent to the Irish land legislation of 1881. He opposed the Home Rule Bill with equal vigour, though Mr Gladstone subsequently stated that, among all the old colleagues who dissented from his course, the duke was the only one whose personal relations with him remained entirely unchanged. Detached from party, the duke took an independent position, and for many years spoke his mind with great freedom in letters to the *Times* on public questions, especially such as concerned the rights or interests of landowners. He was no less active on scientific questions in their relation to religion, which he earnestly strove to reconcile with the progress of discovery. With this aim he published *The Reign of Law* (1866), *Primeval Man* (1869), *The Unity of Nature* (1884), and numerous essays in literary and scientific journals. He also wrote on the Eastern Question, with especial reference to India, the history and antiquities of Iona, patronage in the Church of Scotland, and many other subjects. The duke died 24th April 1900. He was thrice married: first (1844) to a daughter of the second duke of Sutherland (*d.* 1878); secondly (1881) to a daughter of Bishop Claughton of St Albans (*d.* 1894); and thirdly (1895) to Ina Erskine M'Neill. His eldest son, then marquess of Lorne (*b.* 1845), married in 1871 the Princess Louise, fourth daughter of H.M. Queen Victoria. Few men of the duke's era displayed more versatility, and as an orator he ranked very high; but his treatment of the various themes he handled, if always impressive, was rarely conclusive; and while doing something to illustrate every subject and promote every cause which he made his own, and retaining for a generation before he died the deepest public respect—due not only to his career as a public man, but also to his position as the foremost Scottish noble, and the father-in-law of one of his Sovereign's daughters—he can hardly be said to have left any abiding reputation either as politician, thinker, or man of science. (R. G.)

Argyllshire, a maritime Highland county of W. Scotland, embracing a number of the Hebrides or Western Isles, bounded on the N. by Inverness, on the E. by Perth and Dumbarton, Loch Long and the Firth of Clyde, on the S. by the Irish Sea, and on the W. by the Atlantic. It is the second largest county in Scotland.

Area and Population.—In 1891 the Argyll parts of the parishes of Kilmallie and Small Isles were transferred to Inverness-shire. According to the latest official estimate the area of the county (foreshore excluded) is 2,025,154 acres, or about 3165 square miles. The population was in 1881, 76,440; in 1891, 75,003—on the above area, 74,085, of whom 36,292 were males and 37,793 females; on the old area, taking land only (2,056,402 acres or 3213·1 square miles), the number of persons to the square mile in 1891 was 23, and the number of acres to the person 27·4. In the registration county the population decreased between 1881 and 1891 by 1·3 per cent. Between 1881 and 1891 the excess of births over deaths was 8588, and the decrease of the resident population 1451. In 1901 the population was 73,665, a decline of 420. The following table gives particulars of births, deaths, and marriages in 1880, 1890, and 1899:—

Year.	Marriages.	Births.	Deaths.	Percentage of Illegitimate.
1880	299	2108	1557	7·9
1890	282	1803	1360	6·68
1899	303	1749	1338	7·6

The birth-rate, death-rate, and marriage-rate were all below those for Scotland. The following table gives the birth-rate, death-rate, and marriage-rate per thousand of the population for a series of years:—

	1880.	1881-90.	1890.	1891-98.	1899.
Birth-rate . .	26·13	25·24	22·89	22·09	22·48
Death-rate . .	19·30	17·01	17·11	18·63	17·18
Marriage-rate .	3·71	3·88	3·54	3·86	3·89

In 1891 the number of Gaelic-speaking persons in the county was 38,014, of whom 5998 spoke Gaelic only, and there were 52 foreigners. Valuation in 1889-90, £431,554; in 1899-1900, £439,975.

Administration.—The county returns a member to parliament. Inveraray (735) and Campbeltown (8234) are royal burghs, and

Oban (5374) is a parliamentary burgh; all three belong to the Ayr group of parliamentary burghs. Dunoon, with Kirn and Hunter's Quay, is the principal police burgh (6772). There are 39 civil parishes, 26 of which are divided among four combinations of Islay, Lochgilphead, Lorn, and Mull, with poorhouses at Oban, Lochgilphead, Bowmore, and Campbeltown. The number of paupers and dependants in May 1899 was 2383. Argyllshire is a sheriffdom, and there are resident sheriffs-substitute at Inveraray, Campbeltown, Oban, and Fort-William, and courts are held also at Tobermory, Lochgilphead, Bowmore in Islay, and Dunoon.

Education.—Forty-six school boards manage 159 schools, which had an average attendance of 11,117 in 1898-99, while 10 voluntary schools, of which 4 are Episcopal and 2 Roman Catholic, had 877. Campbeltown, Dunoon, and Oban have secondary schools, Tarbert public school has a secondary department, and 19 other schools earned grants in 1698 for giving higher education. Part of the "residue" grant is spent by the county council in subsidizing navigation and other classes in various schools, short courses in agriculture for farmers, and in providing bursaries.

Agriculture.—The greater part of the soil is moor or moss, insusceptible of cultivation, and utilized as grouse and deer forest. The acreage under crops in 1898 was only 6·6 per cent. of the whole. Argyllshire is one of the crofting counties, but crofting is by no means universal. It is predominant in the island of Tiree and the western district of the mainland, but elsewhere farms of moderate size are the rule. In 1695 the average size of the 3272 holdings was 41 acres; the percentage under 5 acres was 32·64; between 5 and 50 acres 47·10, and over 50 acres 20·26. The number of farms between 50 and 100 acres was 304; between 100 and 300, 305; between 300 and 500, 30; and over 500, 24. Oats are the principal corn crop, only about 1500 acres of barley being sown, and there is no wheat at all. Besides stock-raising there is a good deal of dairying in Kintyre, the leading agricultural district. The following table gives the principal acreages at intervals of five years from 1880:—

Year.	Area under Crops.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1880	119,219	23,548	12,761	20,180	61,097	1597
1885	124,797	22,830	11,673	25,112	63,868	1316
1890	133,005	21,486	11,282	27,328	72,389	505
1895	134,063	20,444	10,644	26,999	75,222	725
1699	134,709	19,912	10,348	27,607	76,137	460

The following table gives particulars of the live stock during the same years:—

Year.	Total Horses.	Total Cattle.	Cows or Heifers in Milk or Calf.	Sheep.	Pigs.
1880	7204	59,976	22,385	1,021,948	3758
1885	6930	62,235	23,106	1,000,653	4645
1890	6662	59,627	22,747	1,006,279	4981
1895	7025	60,005	22,446	1,026,712	4905
1699	6367	61,698	22,888	984,301	4285

The acreage under wood in 1895 was 48,412, of which 2068 had been planted since 1881. From the commencement of the operation of the Crofters' Act in 1886 down to the end of 1898, 1097 applications to fix fair rent were dealt with by the Commission, and rents amounting to £6949 were reduced to £4625, and of £12,075 of arrears £7548 were cancelled. The Commissioners have dealt with 146 applications for enlargement of holdings, and have added 4663 acres to existing crofts. At the census of 1891 the number of persons engaged in agriculture was 6234 men and 900 women. Deer forests covered 232,698 acres in 1899, an increase of 16,000 since 1883, and their annual value was £7434.

Industries and Trade.—Coarse woollens are still made for home use. The following table gives particulars of the mineral industry for 1885 and 1895; the figures showing the output of coal cover Dumfries as well as Argyll:—

Year.	Coal.		Slate.		Granite.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1885	105,733	£21,671	17,936	£25,364		
1895	113,945	£28,486	34,340	£60,977	37,211	£13,401
1899	154,786	£58,690	30,580	£62,440	66,128	£19,156

Fishing is the most important industry. Argyllshire ports and creeks are represented in four fishery districts, but as the Rothesay district comprises only a few Argyll ports, statistics may best be given for the fishery districts of Inveraray and Campbeltown, which are exclusively Argyll, and Fort-William, which has 19 Argyll ports out of 26. The following table gives particulars of these three districts in 1890, 1898, and 1899:—

Year.	Boats.			Value of Gear.	Resident Fishermen and Boys.	Total Value of all Fish.
	No.	Tons.	Value.			
1890	1537	6622	£35,807	£31,189	4122	£105,175
1898	1062	4367	£20,000	£20,823	2570	£87,929
1699	1023	3716	£20,225	£20,682	3464	£101,066

£82,902 of the total value of fish in 1899 was the value of herrings only; £6992 the value of shell-fish. In the greater part of the districts the herring fishing is an autumn one. The Lochfyne fishing, which is the most important, lasts from June to January. White fishing is carried on at one or other of the ports all the year round. The number of persons employed in the three districts in connexion with the various branches of the sea fisheries in 1898 was 8873. The railway mileage has been increased by about 56 miles since 1875, and a light railway (18⅜ m.) from Loch Long to Loch Fyne has been sanctioned.

AUTHORITIES.—THE (EIGHTH) DUKE OF ARGYLL. *Commercial Principles Applied to the Hire of Land.* London, 1877.—*Crofts and Farms in the Hebrides.* Edinburgh, 1883.—*Iona.* Edinburgh, 1889.—*Scotland as it Was and Is.* Edinburgh, 1887.—*House of Argyll.* Glasgow, 1871.—A. BROWN. *Memorials of Argyllshire.* Greenock, 1889.—HARVIE-BROWN and BUCKLEY. *Vertebrate Fauna of Argyll and the Inner Hebrides.* Edinburgh, 1892.—D. CLERK. "On the Agriculture of the County of Argyll" (*Trans. of H. and A. Soc.* 1878).—T. GRAY. *Week at Oban.* Edinburgh, 1881.—STEWART. *Collection of Views of Campbeltown.*

(W. WA.)

Argyrokastro, or ERGERI, a town of Turkey, on the river Drina in South Albania (Epirus). It is the chief town of the sanjak of the same name, which is one of the four composing the vilayet of Janina as reduced by the annexation of Thessaly to Greece. Its population numbers 9000.

Arica or **San Marcos de Arica,** a town and port in the Chilian province of Tacna and capital of the department of Arica, situated in 18° 28′ 8″ S. lat. and 70° 20′ 46″ W. long. Its population in 1895 was 2853. It is the centre of a great mining district, and is connected with Tacna by rail. The territory of Arica and of Tacna fell into Chilian hands during the war of 1879 with Peru. In 1898, 295 vessels of 493,447 tons entered, and 296 of 494,784 tons cleared. The customs dues on imports into Arica in 1897 were 144,713 pesos (gold), and in 1898, 99,084.

Ariège, a department in the S. of France, resting on the Pyrenees and watered by the Ariège.

Area, 1893 square miles. The population declined to 237,619 in 1886, 219,641 in 1896, and 202,284 in 1901. Births in 1899, 4004, of which 149 were illegitimate; deaths, 4374; marriages, 1543. The chief towns are Foix, Pamiers, and St Girons. In 1896 the schools numbered 776, with 32,000 pupils. Eight per cent. of the population was illiterate. The area cultivated was 917,839 acres, of which 353,269 acres was plough-land. The mountains give very good pasture. In 1899 wheat yielded a return of the value of £225,037. Maize is also a profitable culture, as are likewise potatoes, which gave a return of 2,035,145 cwts. in 1898. Among the industrial cultures flax is the only noteworthy one. In 1899 the live stock numbered 573,560 head. Ariège produced in 1898 28,000 tons of iron ore, and 23,000 tons of copper, argentiferous lead, and manganese (mines of Nicdessos). The metallurgic industry yielded 48,000 tons of iron, cast-iron, and steel, of the value of £304,000. The other industries, with the exception of the manufacture of paper, are inconsiderable.

Arish. See ARABIA.

Aristides, Apology of.—Until 1878 our knowledge of Aristides was confined to the statement of Eusebius that he was an Athenian philosopher who presented an apology "concerning the faith" to the Emperor Hadrian. In that year, however, the Mechitarists of S. Lazzaro at Venice published a fragment in Armenian from the beginning of the apology; and in 1889 Dr Rendel Harris found the whole of it in a Syriac version on Mount Sinai. While his edition was passing through the press, it was observed by the present writer that all the while the work had been in our hands in Greek, though in a slightly abbreviated form, as it had been imbedded as a speech in a religious novel written about the 6th century and entitled "The Life of Barlaam and Josaphat." The discovery of the Syriac version reopened the question of the date of the work. For although its *title* there corresponds to that given by the Armenian fragment and by Eusebius, it begins with a formal inscription to "the Emperor Titus Hadrianus Antoninus Augustus Pius": and Dr R. Harris is followed by Harnack and others in supposing that it was only through a careless reading of this inscription that the work was supposed to have been addressed to Hadrian. If this be the case, it must be placed somewhere in the long reign of Antoninus Pius (138-161). There are, however, no internal grounds for rejecting the thrice-attested dedication to Hadrian his predecessor, and the picture of primitive Christian life which is here found points to the earlier rather than to the later date. It is possible that the apology was read to Hadrian in person when he visited Athens, and that the Syriac inscription was prefixed by a scribe on the analogy of Justin's Apology, a mistake being made in the amplification of Hadrian's name.

The Apology opens thus: "I, O king, by the providence of God came into the world; and having beheld the heaven, and the earth, and the sea, the sun and moon, and all besides, I marvelled at their orderly disposition; and seeing the world and all things in it, that it is moved by compulsion, I understood that He that moveth and governeth it is God. For whatsoever moveth is stronger than that which is moved, and whatsoever governeth is stronger than that which is governed." Having briefly spoken of the divine nature in the terms of Greek philosophy, Aristides proceeds to ask which of all the races of men have at all partaken of the truth about God. Here we have the first attempt at a systematic comparison of ancient religions. For the purpose of his inquiry he adopts an obvious threefold division into idolaters, Jews, and Christians. Idolaters, or, as he more gently terms them in addressing the Emperor, "those who worship what among you are said to be gods," he subdivides into the three great world-civilizations—Chaldeans, Greeks, and Egyptians. He chooses this order so as to work up to a climax of error and absurdity in heathen worship. The direct nature-worship of the Chaldeans is shown to be false, because its objects are works of the Creator, fashioned for the use of men. They obey fixed laws and have no power over themselves. "The Greeks have erred worse than the Chaldeans . . . calling those gods who are no gods, according to their evil lusts, in order that having these as advocates of their wickedness they may commit adultery, and plunder and kill, and do the worst of deeds." The gods of Olympus are challenged one by one, and shown to be either vile or helpless, or both at once. A heaven of quarrelling divinities cannot inspire a reasonable worship. These gods are not even respectable: how can they be adorable? "The Egyptians have erred worse than all the nations; for they were not content with the worships of the Chaldeans and Greeks, but introduced, moreover, as gods even brute beasts of the dry land and of the waters, and plants and herbs. . . . Though they see their gods eaten by others and by men, and burned, and slain, and rotting, they do not understand concerning them that they are no gods."

Throughout the whole of the argument there is strong common-sense and a stern severity unrelieved by conscious humour. Aristides is engaged in a real contest; he strikes hard blows, and gives no quarter. He cannot see, as Justin and Clement see, a striving after truth, a feeling after God, in the older religions, or even in the philosophies of Greece. He has no patience with attempts to find a deeper meaning in the stories of the gods. "Do they say that one nature underlies these diverse forms? Then why does god hate god, or god kill god? Do they say that the histories are mythical? Then the gods themselves are myths, and nothing more."

The Jews are briefly treated. After a reference to their descent from Abraham and their sojourn in Egypt, Aristides praises them for their worship of the one God, the Almighty Creator; but blames them as worshipping angels, and observing "sabbaths and new moons, and the unleavened bread, and the great fast, and circumcision, and cleanness of meats." He then proceeds to the description of the Christians. He begins with a statement which, when purged of glosses by a comparison of the three forms in which it survives, reads thus: "Now the Christians reckon their race from the Lord Jesus Christ; and He is confessed to be the Son of God Most High. Having by the Holy Spirit come down from heaven, and having been born of a Hebrew virgin, He took flesh and appeared unto men, to call them back from their error of many gods; and having completed His wonderful dispensation, He was pierced by the Jews, and after three days He revived and went up to heaven. And the glory of His coming thou canst learn, O king, from that which is called among them the evangelic scripture, if thou wilt read it. He had twelve disciples, who after His ascent into heaven went forth into the provinces of the world and taught His greatness; whence they who at this day believe their preaching are called Christians." This passage contains striking correspondences with the second section of the Apostles' Creed. The attribution of the Crucifixion to the Jews appears in several 2nd-century documents; Justin actually uses the words "He was pierced by you" in his dialogue with Trypho the Jew.

"These are they," he proceeds, "who beyond all the nations of the earth have found the truth: for they know God as Creator and Maker of all things, and they worship no other god beside Him; for they have His commandments graven on their hearts, and these they keep in expectation of the world to come. . . . Whatsoever they would not should be done unto them they do not to another. . . . He that hath supplieth him that hath not without grudging: if they see a stranger they bring him under their roof, and rejoice over him, as over a brother indeed, for they call not one another brethren after the flesh, but after the spirit. They are ready for Christ's sake to give up their own lives; for His commandments they securely keep, living holily and righteously, according as the Lord their God hath commanded them, giving thanks to Him at all hours, over all their food and drink, and the rest of their good things." This simple description is fuller in the Syriac, but the additional details must be accepted with caution: for while it is likely that the monk who appropriated the Greek may have cut it down to meet the exigencies of his romance, it is the habit of certain Syriac translators to elaborate their originals. After asserting that "this is the way of truth," and again referring for further information to "the writings of the Christians," he says: "And truly this is a new race, and there is something divine mingled with it." At the close we have a passage which is found only in the Syriac, but which is shown by internal evidence to contain original elements: "The Greeks, because they practise foul things . . . turn the ridicule of their foulness upon the Christians." This is an allusion to the charges of Thyestean banquets and other immoralities, which the early apologists constantly rebut. "But the Christians offer up prayers for them, that they may turn from their error; and when one of them turns, he is ashamed before the Christians of the deeds that were done by him, and he confesses to God saying: 'In ignorance I did these things'; and he cleanses his heart, and his sins are forgiven him, because he did them in ignorance in former time, when he was blaspheming the true knowledge of the Christians."

These last words point to the use in the composition of this Apology of a lost apocryphal work of very early date, *The Preaching of Peter*. This book is known to us chiefly by quotations in Clement of Alexandria: it was widely circulated, and at one time claimed a place within the Canon. It was used by the Gnostic Heracleon and probably by the unknown writer of the epistle to Diognetus. From the fragments which survive we see that it contained: (1) a description of the nature of God, which closely corresponds with Arist. i., followed by (2) a warning not to worship according to the Greeks, with an exposure of various forms of idolatry; (3) a warning not to worship according to the Jews—although they alone think they know the true God—for they worship angels and are superstitious about moons and sabbaths, and feasts, comp. Arist. xiv.; (4) a description of the Christians as being "a third race," and worshipping God in "a new way" through Christ; (5) a proof of Christianity from Jewish prophecy; (6) a promise of forgiveness to Jews and Gentiles who should turn to Christ, because they had sinned "in ignorance" in the former time. Now all these points, except the proof from Jewish prophecy, are taken up and worked out by Aristides with a frequent use of the actual language of *The Preaching of Peter*. A criterion is thus given us for the reconstruction of the Apology, where the Greek which we have has been abbreviated, and we are enabled to claim with certainty some passages of the Syriac which might otherwise be suspected as interpolations.

The style of the Apology is exceedingly simple. It is curiously misdescribed by Jerome, who never can have seen it, as "Apologeticum pro Christianis contextum philosophorum sententiis." Its merits are its recognition of the helplessness of the old heathenism to satisfy human aspiration after the divine, and the impressive simplicity with which it presents the unfailing argument of the lives of Christians.

The student may consult *The Apology of Aristides*, Syriac text and translation (J. R. HARRIS), with an appendix containing the Greek text, *Texts and Studies*, i. 1 (1891), and a critical discussion by R. SEEBERG in Zahn's *Forschungen*, v. 2 (1893); also, brief discussions by HARNACK, *Altchristl. Litteratur*, i. 96 *ff.*, *Chronologie*, i. 271 *ff.*, where references to other writers may be found.

(J. A. R.)

Arithmetic. See NUMBER.

Arizona.—A territory of the United States, lying on the south-western border, between 37° and from 32°·8 to 33°·5 N. lat., and 109° and from 114°·8 to 114° W. long.; and bounded on the N. by Utah, on the E. by New Mexico, on the S. by Mexico, and on the W. by California and Nevada. It is traversed from the north-west to the south-east, a distance of about 450 miles, by mountain ranges of the Great Basin system which form the main axis of elevation. On the north-east side, the great Colorado Plateau, with an average elevation of from 6000 to 8000 feet, stretches away into Utah and New Mexico. The southern margin of this plateau, marked by a line of cliffs, divides the head waters of the Colorado Chiquito from those of the Gila. The plateau is dominated in its middle southern portion, north of Williams and Flagstaff, by a series of extinct volcanic cones, reaching in San Francisco Mountain an altitude of nearly 13,000 feet, from which in late Tertiary time great floods of lava flowed, chiefly to the southward and westward, forming a protecting covering to the foundation of nearly horizontal sedimentary rocks through which, on the north side, the Colorado carved the Great Cañon. Southward and westward from the central mass of mountains the surface slopes away to the Gulf of California in a series of wide valleys, separated by isolated mountain ranges, preserving a general parallelism in a north-west and south-east direction. Of the approximate total area of 113,000 square miles, about 39,000 are below the altitude of 3000 feet; about 27,000 are from 3000 to 5000 feet, and 47,000 are over 5000 feet. The central mountain ranges are largely formed of granitic, porphyritic, and other plutonic rocks in great variety, including volcanic outflows and tufas. There are areas of Archæan gneiss and pre-Cambrian slates flanked by Palæozoic formations, especially by the Devonian and Carboniferous. Great beds of Palæozoic conglomerate and breccias give evidence of continental areas, shallow oceans, and beaches in the earlier ages, with currents of great volume and power. Well-marked horizons of the Devonian occur in the Santa Catalina and the Santa Ritas. Carboniferous limestones and sandstones are widely distributed in the southern isolated mountain ranges and are uplifted, flexed, and faulted. Beds of graphitic coal with much ash and of little or no value for fuel have been found, and show the far westward extension of the flora of the Coal Measures. Sandstones of the Permian underlie a part of the lava of San Francisco Mountain, and Mesozoic beds crop in many places towards the south and west. Fossil bones and teeth of both the mammoth and the mastodon, and of a giant species of *Bos*, show that some at least of the large extinct mammals roamed over the Pleistocene plains and valleys.

Shut in on all sides from the ocean by mountain ranges and wide areas of land, Arizona is without rain for the greater part of the year. The air is clear, and the rays of the unclouded sun have great power. At night the radiation is unobstructed and the temperature falls rapidly. Owing to the extreme dryness of the air the evaporation from all moist surfaces is rapid, and the high temperatures shown by the dry-bulb thermometer are less oppressive than much lower temperatures in a humid atmosphere. There is a short season of rain in the spring, and one in midsummer, and the accumulation of snow on the mountains in winter gives rise to springs, rivulets, and forest growth.

The native plants, especially upon the lower levels, are characteristic of arid and semi-desert regions. They are Sonoran rather than Californian in aspect and grouping. Altitude, with its increasing moisture conditions and lower temperature, is a greater factor in the geographic distribution than latitude. Thorny shrubs, cactaceæ, and yuccas abound on the plains, together with the mesquite and paloverde, wherever their deeply-extended roots can reach moisture or water. The *Larrea Mexicana*, the evergreen shrub with aromatic glossy leaves and bright yellow flowers, is rarely absent and thrives under the most adverse conditions. Of Cacti there are no less than seventy-five species. The giant columnar cactus (*Cereus giganteus*), sometimes 40 feet high, is a striking object. Along the streams the cottonwood, sycamore, ash, willow, and walnut give verdure and shade. At an elevation of about 4000 feet oak trees appear in cañons and on the foot hills, giving the country the aspect of an artificial park. In the Huachuca Mountains there are eleven species of oak, most of them evergreen. At higher levels junipers, cedars, and cypress appear and give place in the region of snow to firs and pines which crown the summits of most of the mountain ranges, attaining their greatest development and commercial importance on the Colorado plateau. This is known as the Coconino Forest, and is one of the most extensive forest areas in the United States, a large part of which has been reserved by the Government. The trees are mostly the yellow pine (*Pinus ponderosa*), and its varietal forms, the most widely disseminated and most abundant tree of the interior forest area, and practically the only tree of commercial importance for lumber. It is estimated that the total quantity of pine lumber fit for sawing within the limits of Arizona is not less than 8,000,000,000 feet B.M. The principal lumber mills are at Flagstaff and Williams in Coconino county.

The manufactures are few and of comparatively small value, excepting lumber. A large flouring mill has been erected at Tucson, and there are also extensive railway repair shops, a foundry, and mining machinery plant. At Phœnix onyx marble is cut and polished by machinery and Indian labour. The Navajo and the Moqui Indians make woollen blankets and rugs, and the Pimas baskets.

There are four chief regions of valleys of great fertility especially adapted to agriculture: the Salt River Valley, the Upper Gila and its tributaries, the Lower Gila and the Colorado, and the Santa Cruz. The Salt River Valley has one of the largest known tracts of irrigable land in one body, estimated at 1,500,000 acres. Numerous irrigating canals have partly redeemed it from the desert-like condition to which it relapsed after the disappearance of the ancient Aztec population. It is a region of beautiful farms, gardens, and orchards. Alfalfa, the staple forage and hay crop, thrives luxuriantly, and as many as five cuttings a year are possible. In 1898 some 35,000 cattle, fattened on alfalfa, were shipped from this valley. Corn, wheat, and barley are grown, but the region is chiefly celebrated for its early crops of citrus fruits, grapes, figs, dates, pomegranates, and olives. The date-palm flourishes. The most desirable varieties have been introduced. Considerable promise attends the cultivation of the sugar-beet and the experiments upon canaigre as a source of tannin. Excluding farms of Indians, there were in 1900, 4040 farms, containing 1,891,985 acres (of which 12 per cent. were improved land), valued, with improvements, at $13,088,550. Over 72 per cent. of the total farm acreage in the territory and nearly 20 per cent. of the value of farm property were credited to 71 farms of 1000 acres or more each. In 1899 there were 2052 farms devoted principally to producing hay and grain, and 2343 to live stock. The average value of all farms in the territory was $5148, and of products in 1899 not fed to live stock, per farm, $1064. In 1900 there were on farms and ranges 7,042,635 neat cattle, 125,063 horses, 4077 mules, 4625 asses, 861,761 sheep, 18,103 swine, and 98,403 goats. Of the neat cattle nearly 98 per cent. and of the sheep nearly 100 per cent. were pastured wholly or in part upon the public domain. The value of all live stock was $15,458,717, or 15·7 per cent. of the total capital invested in agriculture. It has been estimated that Arizona is capable of maintaining 8,000,000 head of cattle, but in the past an overstocking of the ranges has caused much loss and suffering, and the almost total eradication of the fine native grasses over extended areas. The total value of all farm crops in 1899 was $2,474,296, of which the hay and forage crops amounted to $1,361,422. The total value of all farm products, including animals sold or slaughtered for food ($3,204,758), was $6,997,097. Of the total improved land (227,890 acres) outside of Indian reservations in 1899, 81 per cent. was irrigated land; the total increase of irrigated land from 1890 to 1900 was 119,575 acres. In 1899 there were 1492 miles of irrigation ditches, the construction cost of which was $4,408,158. The raising of ostriches for their feathers is successful.

The production of copper increased from 17,398 tons in 1890 to 55,412 tons in 1898, and over 76,000 tons in 1899. The chief centres of production are Bisbee, Jerome, Clifton, and Globe. Several gold-mines are worked to a great depth. The production of gold and silver, chiefly gold, was approximately $4,500,000 in value for 1899. Wolframite, an ore of tungsten, occurs in quantity and has been successfully worked. There are also valuable ores of molybdonum and vanadium. Quarries of onyx marble have been opened, and some fine gems of peridot, garnet, and turquoise have been found.

Two transcontinental systems of railways, the Southern Pacific and the Santa Fé Pacific, traverse the state from east to west, and are connected from north to south by several lines. There are in all 999·5 miles of railway, with an assessed valuation of $4,189,075.20 on which taxes are paid, and 454 miles of road exempt from taxation for a term of years. A standard gauge railway has been laid from Williams to the Grand Cañon.

On 1st July 1899 the county and city funded indebtedness was $1,634,027.57, and the bonded debt of the Territory $1,041,972.43. There are five national banks with an aggregate capital of $400,000, deposits $2,194,773; and seven territorial banks, capital $219,700, deposits $1,364,475.

According to the census of 1890 the population was 59,620. In 1900 it was 122,212, showing an increase for the decade of 62,592, or 104·9 per cent. The increase was due in part to the fact that there were 28,623 Indians or other persons on Indian reservations in 1890, but not included in the general population as shown by the census bulletins. The average number of persons per square mile was 1·0 in 1900, as compared with 0·5 in 1890. The three principal cities, Phœnix (the capital), Tucson, and Prescott, have respectively 5544, 7531, and 3559 inhabitants. The Indian population in 1890 was 58,540. In 1899 the number enrolled at the five Government agencies and under instruction was 39,744. Many friendly Papagoes in Papagueria are not included. Of the total 20,500 are upon the Navajo reservations, and 2641 at the Hopi Pueblo. The Territorial prison, located at Yuma, had in 1898, 214 male prisoners.

The public-school system was established in 1871, and is modelled after that of California. There are primary, grammar, and high schools, and two normal schools, one at Tempe in Maricopa county and one at Flagstaff. In 1900 there were 373 teachers, 251 women and 122 men, of whom 120 were graduates of normal schools; the total number of enrolled students was 15,898, and the average daily attendance 9396. The total expenditure for the school year ending 30th June 1899 was $238,741. The Territorial University, including the School of Mines and the laboratories of the Agricultural Experiment Station, was established at Tucson in 1885 and was opened in October 1891. It has about 20 professors and instructors, and from 140 to 150 students. It is well equipped for instruction and investigation, and is sustained chiefly by the Morrill and Hatch funds amounting to about $45,000 annually. A school for Indians at Phœnix, and one at San Carlos, are sustained by the United States. One at Tucson, with an average of 150 boys and girls, is supported by the Presbyterian Home Mission. There are 53 or more newspapers; 11 daily and 42 weekly, including 3 published in Spanish. There is an important and well-selected reference library at the university. The Carnegie Library building, under construction, will receive the valuable Territorial Library collection of some thousands of volumes.

The Territorial Assembly meets biennially. A new Capitol of granite and white tufa has been erected at a cost of about $150,000. There have been fourteen different governors between 1863 and 1900. There are four judicial districts, in which court is held twice a year. One chief justice and four associates are appointed by the president.

The early Spanish colonists of Mexico were incited to the exploration and settlement of the region by the reports of its wealth of precious metals and precious stones. In 1539 Padre Merco de Niza passed through the valley of the Santa Cruz, and was followed in 1540 by Coronado. A mission was established at Gueveiz, south of Tucson, in 1687, and thirty-three years later there were nine missions within the limits of the territory now known as Arizona. The converts were mostly from the Pime tribe, and after baptism were called Pepago. New Mexico, which included all of Arizone north of the Gila river, was ceded to the United States in 1848. The strip of country south of the Gila, known as the Gadsden Purchase, was acquired in 1853. Arizona was set off from New Mexico and organized as a territory in 1863.

See HAMILTON. *Resources of Arizona*, 3d edit. 1884.—*Report of the Governor of Arizona to the Secretary of the Interior*, 1899. **For Grand Canon**: DUTTON. *Tertiary History of the Grand Cañon District*, 4to. 1882. U.S. Geol. Sur.—POWELL. *Exploration of the Colorado River*. 1875. **Cattle Industry**: CAMERON. *Report Gov. Arizona*. 1896. **Agriculture and Horticulture**: TOUMEY. *Report Gov. Arizona*. 1898. (W. P. B.)

Arkansas, one of the Southern States of the American Union, situated between 36° 30′ and 33° N. lat., and 89° 49′ and 94° 30′ W. long., and bounded on the W. by the Mississippi, on the S. by Louisiana, on the E. by Texas and Indian Territory, and on the N. by Missouri. Before 1875, because of the nature of its physical features—being swampy in the lowlands, everywhere covered with forests, and mountainous in the north-west—and because, too, of the political conditions after the Civil War, Arkansas attracted but little of the great stream of immigration that had peopled the flat lands to the north and the prairies to the south. The main development of the state dates from 1890. If a line be drawn from where the Black River cuts the northern boundary to where the Red cuts the western, east of it will lie the lowlands and forests, and to the west will lie the mountains. North of the Arkansas river, in the region of the Boston mountains and the Ozarks, the country is very broken. The general elevation of the land is between 800 and 1200 feet above sea-level; the mountains are scattered in broken ridges and spurs as if flung from a gigantic hand, and there are few peaks of imposing height, the loftiest being Boat Mountain and Lost Mountain, each 2200 feet above sea-level. South of the Arkansas, the mountains lie in long high ranges east and west, separated by low fertile valleys, and at times rising into fine and imposing peaks. Magazine Mountain, 2823 feet above sea-level and 2350 feet above the surrounding country, is the loftiest point between the Alleghanies and Rockies, and in beauty and grandeur surpasses the famous Lookout. Blue Mountain, 2800 feet, and Mt. Mena (Rich Mountain), 2750 feet, each rises 2100 feet over its valley. The state is well watered, and there are 3000 miles of navigable rivers. Locks have been constructed on White River, a fine stream, navigable 300 miles of its length. In its passage through the mountains White River may be compared with the Hudson for beauty of scenery. Its name it takes from the clearness of its waters, which it remarkably preserves through the alluvial lands even to its mouth.

The mineral history of the state may be dated from 1887, when the larger operations in coal began. The coal area covers 9100 square miles in the western part of the state, and extends into the Indian Territory over 20,000 square miles. Its quality is semi-anthracite and semi-bituminous, and, being hard and smokeless, is valuable for domestic and steam uses. From an output of 129,000 short tons in 1887, the production had swollen to 1,173,804 tons in 1898. The development is very rapid: in 1901 the daily output was about 10,000 short tons, with an employment of 3920 miners. The production from the adjacent coal-fields of the Indian Territory about doubles that of Arkansas. In the northern part of the state 2199 square miles of lead and zinc fields have been opened, the zinc fields undoubtedly constituting one of the richest deposits in the world. Between 1888 and 1892 Prof. John C. Branner made an exhaustive geological survey, the results of which have been published by the state; and his account of the location, extent, and economic value of mineral deposits has, in several instances, led to their practical development. His reports show that one of the "most valuable deposits of manganese in North America" lies in the north-east, that payable quantities of iron are found in the same section, that 4450 square miles of marble equal to the best Tennessee varieties are situated in the north, that limestone valuable for lime is to be had in inexhaustible quantities, that granites superior to any known exist near Little Rock, that the finest novaculites and whetstones yet found are in abundance in the southern mountains, that antimony and bauxites are found in abundance, that clays and kaolin fit for manufacture of the best grade of porcelain exist in great quantities in the south central portion, and that the greensand, gypsum, and chalk marls in the south, if properly utilized, "will be of more value to the state than all the gold dug within the bounds of California has been to that state." A large deposit of true chalk has been utilized by a company which produces Portland cement. Gold and silver are also to be found, but not in extensive or valuable quantities.

The alluvial bottoms are exceedingly productive, and the soil and climate of the higher regions are peculiarly adapted to fruit-growing. The chief staple is cotton. In 1899, 1,726,000 acres produced 770,000 bales, valued at $30,800,000. In 1897, 922,000 were raised, and the crop of 1900, with an acreage of 1,899,000, was estimated at over 900,000 bales, valued at $35,000,000. Other agricultural products, in order of value, are corn, oats, wheat, rye, hay, millet, fruits (particularly apples, berries, and peaches), potatoes, field peas, sugar-cane, sorghum, broom corn, and rice. It is estimated that in 1898 the fruit and vegetable shipments were as follows:—Apples, 2400 carloads; berries, 1000; peaches, 500; and potatoes, 1200 carloads. The fruit is of finest quality, especially the apples, to which the first prize has been awarded in every competition since 1885, including the World's Fair in 1893 at Chicago. Lumber has been extensively cut, and in 1898 the shipments amounted to over 50,000 carloads. The annual output of forest products is valued at over $20,000,000. The forests cover over 25,000,000 acres.

There are 54 railways (including branches and leased lines worked under distinct names), with a total of 3052 miles, and an assessed value of $24,051,139. The principal systems are the St. Louis, Iron Mountain, and Southern, which with branches and leased lines has 1059 miles; the St Louis South-Western, 412; the Choctaw and Memphis, 282; the Kansas City, Fort Scott, and Memphis, 162; the Kansas City Southern, 153; and the St Louis and San Francisco, 108. The total assessed value of real estate in 1899 was $127,062,908; of personal property, \$62,936,142; total, \$189,999,050. The rate of taxation for state purposes was 2¼ mills for general revenue, 2 mills for common schools, 1 mill for sinking fund, and ¼ of a mill for pensions; total, 5½ mills. The constitution limits taxation by the state to 10 mills, and by counties for county purposes to 5 mills. The statutes limit taxation for city purposes to 5 mills, and for schools to 5 mills. The annual general expenses of the state government average about \$500,000. The total revenue from all sources in 1897 was \$2,229,682.

The growth in population is shown by the following table:—

Year.	Whites.	Negroes.	Total.[1]
1870	362,115	122,169	484,471
1880	591,531	210,666	802,525
1890	818,752	309,117	1,128,179
1900	944,580	366,856	1,311,436

The increase for the last decade of the 19th century was 16·25 per cent. The total land surface is approximately 53,045 square miles, and the average number of persons to the square mile was, therefore, 24·73 in 1900, as compared with 21·27 ten years earlier. Of the cities or towns in the state nineteen had in 1900 a population in excess of 2000, and five in excess of 5000. These five were Little Rock with 38,307, Fort Smith with 11,587, Pine Bluff with 11,496, Hot Springs with 9973, and Helena with 5550. The blacks are confined to the eastern part of the state; slavery never penetrated the mountainous portion, and the conditions there more nearly resemble those of Missouri than of the Gulf States.

The common school system is well developed; the number of school-houses in 1898 was 4926; the value of school properties was \$2,294,396. The scholastic population in 1898 was 336,168 whites and 129,397 blacks; total, 465,565. The total enrolment in 1898 was 224,247 whites and 79,561 blacks; total, 303,808. The state supports an agricultural and industrial university at Fayetteville. A number of sectarian and private colleges and academies have been established. In 1898 there were in all eight institutions for higher education, all co-educational; the students, including those in the preparatory departments, numbered 1072 men and 564 women; the teachers, 78 men and 30 women. There were 22,708 volumes in the libraries. The state supports a lunatic asylum, a blind school, and a deaf mute institute at Little Rock.

In 1900 there were 7 national banks, with a capital of \$1,070,000; 104 state banks, with a capital and surplus of \$3,855,761; 6 private banks, with a capital and surplus of \$196,291; and 2 loan and trust companies, with capital and surplus of \$79,000.

There were 3791 church edifices, and the church property was valued at \$3,266,663. The communicants or members numbered 296,208, of whom 128,724 were Baptists, 123,316 Methodists, 18,022 Presbyterians, and 14,385 Disciples of Christ.

After the Reconstruction Act of 1867, all offices, state and county, fell into the hands of "carpet-baggers," who inaugurated a reign of force and corruption. The native whites, practically disfranchised, fell under a rule of strangers, based on a suffrage conferred on their former slaves. In political self-defence, they responded with force and with frauds against the ballot. Secret societies were formed, such as the Ku Klux Klan on the one side, and the Brothers of Freedom on the other. The reconstruction governor organized a militia and declared martial law in several counties, but this only aggravated the mischief. In 1873, the "regular" Republicans elected Elisha Baxter as governor over Joseph Brooks, the nominee of the reform Republicans. The Democrats had no candidate, but supported Brooks. Governor Baxter, by an honest and just conduct of the administration, soon alienated the affections of the "regular" Republicans who had elected him. Deserting him, they joined Brooke in a legal contest for the office. The Republican Court, in which the contest was filed on 15th April 1874, entered judgment for Brooke in the absence of Baxter and without notice. Brooke in person, accompanied by a guard, went to the State House, ousted Baxter, and entrenched himself there. The Democrats, espousing Baxter's cause, flew to arms. The turmoil that followed is known as the Brooks-Baxter War. The matter was referred to the President, and the attorney-general delivered an opinion favourable to Baxter. On 15th May the President issued a proclamation declaring him entitled to the office, and ordering the Brooke forces to disperse. Since then, the state has been in the hands of the Democrat party. (E. E. B.)

Arkansas City, a city of Cowley county, Kansas, U.S.A., situated in 37° 04′ N. lat. and 97° 03′ W. long., near the southern boundary of the state, on the north bank of the Arkansas, at an altitude of 1073 feet. Its site is a level bottom land, and its streets are laid out according to a regular plan. It is a supply point for a rich agricultural region and is entered by four lines of railway, the Atchison, Topeka, and Santa Fé; the Missouri Pacific; the St Louis and San Francisco; and the Kansas South-Western railways. Population (1900), 6140.

Arkhangelsk, or Archangel, a government of N. Russia, on the Arctic Ocean. Area, 331,505 sq. miles. Population (1897), 347,589. The peninsula of Kola, as also the islands Kolguev, Vaigach, and Novaya Zemlya, belong to it. In 1899, 170,540 acres were under cereals. Forests cover nearly one-half of the total area, and provide hunting, as well as an opportunity for various important industries connected with wood (timber, pitch, and tar, etc.). Cattle-breeding is at a low stage; but there were in 1897, 42,600 horses, 105,760 cattle, and 125,000 sheep, and the race of Kholmogory cows is kept in high repute. The coasting trade between the town of Arkhangelsk and the Murman or Norman coast and St Petersburg has lately been on the increase, but the value of foreign exports has declined (£1,234,390 in 1874, and £833,823 in 1898; imports, £130,000). Archangel is divided into ten districts, of which the chief towns are—Arkhangelsk (population, 20,933 in 1897), now connected by a railway (525 miles) with Yaroslavl; Kem (1825); Kola (615); Kholmogory (1465); Mezeñ (2040); Onega, (2700); Ust Tzylma, in Pechora district; Pinega (1000); and Shenkursk (1308). A new military harbour has been established on the Murman coast at Alexandrovsk, in the unfreezing Ekaterininskaya Bay.

Arklow, a maritime town in the county of Wicklow, Ireland, 50 miles south of Dublin by rail. In 1882 an Act was passed providing for the improvement of the harbour and for the appointment of harbour commissioners. The town hall and the new Protestant church (1899) were both the gift of the Earl of Carysfort. Cordite works have recently been established. The number of vessels registered in the fishing district in 1898 was 170, employing 808 men and boys. Population, 4172.

Arlington, (1) a town of Middlesex county, in eastern Massachusetts, U.S.A., traversed by the Boston and Maine railway; known until 1867 as West Cambridge. Population (1900), 8603. (2) A soldiers' cemetery under the control of the U.S. Government, situated in northern Virginia, in Alexandria county, on the bluffs of the south bank of the Potomac, opposite the city of Washington. Sixteen thousand victims of the Civil War, among them numerous prominent officers, including General Sheridan, are buried here.

---

[1] Including Indians and Chinese.

The place was formerly the estate of the Lee family, and was confiscated by the Government, the family finally receiving payment for it. The grounds are beautifully laid out, and the old Lee mansion remains unchanged.

Armagh, an inland county of Ireland, province of Ulster, bounded on the N. by Lough Neagh, on the W. by Down, on the S. by Louth, and on the W. by Monaghan and Tyrone.

Population.—The area of the administrative county in 1899 was 312,659 acres, of which 132,269 were tillage, 141,455 pasture, 514 fallow, 3141 plantation, 6416 turf bog, 2493 marsh, 7473 barren mountain, and 18,898 water, roads, fences, &c. The new administrative county under the Local Government (Ireland) Act, 1898, does not include the portion of the town of Newry, formerly situated in Armagh. Population (1881), 163,177; (1891), 143,289; (1901), 125,238, of whom 59,687 were males and 65,551 females, divided as follows among the different religious sects:—Roman Catholics, 56,707; Protestant Episcopalians, 40,853; Presbyterians, 20,029; Methodists, 5066; and other denominations, 2583. The decrease of population between 1881 and 1891 was 12·19 per cent. and between 1891 and 1901 it was 9·2 per cent. Of the total population in 1891, 107,180 persons inhabited the rural districts, an average of 255 persons to each square mile under crops and pasture.

Education.—The following table gives the degree of education in 1891:—

	Males.	Females.	Total.	Percentage.		
				R.C.	Pr. Epis.	Presb.
Read and write .	41,979	42,381	84,360	55·9	68·1	82·6
Read only . .	8,078	12,324	20,402	17·3	16·6	11·3
Illiterate . . .	10,864	13,120	23,984	26·8	15·3	6·1

In 1881 the percentage of illiterates among Roman Catholics was 32·6. In 1891 there were 19 superior schools with 428 pupils (133 Roman Catholics and 295 Protestants), and 290 primary schools with 20,655 pupils (8996 Roman Catholics and 11,659 Protestants). The number of pupils on the rolls of the national schools on 30th September 1899 was 24,332, of whom 10,795 were Roman Catholics and 13,537 Protestants.

The following table gives the number of births, deaths, and marriages in various years:—

Year.	Births.	Deaths.	Marriages.
1881	4874	3665	982
1891	3394	2926	694
1899	2842	2480	683

In 1899 the birth-rate per 1000 was 20·6, and the death-rate 18·0; the rate of illegitimacy was 3·5 per cent. of the total births. The total number of emigrants who left the county between 1st May 1851 and 31st December 1899 was 93,620, of whom 52,339 were males and 41,281 females. The following are the chief towns in the county, with their populations in 1901:—Armagh, 7569; Lurgan, 11,777; Portadown, 10,046. A portion of the borough of Newry was formerly in Armagh, but in 1898 it was added to Down.

Administration.—The county is divided into three parliamentary divisions, north, middle, and south, the number of registered electors in 1900 being respectively 10,114, 7363, and 7152. The rateable value in 1900 was £430,162. By the Local Government (Ireland) Act, 1898, the fiscal and administrative duties of the grand jury and (to a less extent) of other bodies were transferred to a county council, urban and rural district councils were established, and under that Act the county now comprises four urban and five rural sanitary districts.

Agriculture.—The following tables show the acreage under crops, including meadow and clover, and the amount of live stock in 1881, 1891, 1895, and 1899. The figures for 1899 are for the new administrative county:—

	Wheat.	Oats.	Barley, Beans, etc.	Potatoes.	Turnips.	Other green Crops.	Flax.	Meadow and Clover.	Total.
1881	7161	56,165	879	28,150	7739	2075	16,012	45,172	165,353
1891	2758	51,055	846	26,434	8049	2592	4,965	49,971	146,171
1895	1204	49,054	237	24 692	8198	1965	8,244	53,121	146,620
1899	1468	46,344	179	22,370	8227	1729	1,531	50,121	132,269

For 1899 the total value of the cereal and other crops was estimated by the Registrar-General at £866,848. The number of acres under pasture in 1881 was 112,655; in 1891, 126,130; and in 1899, 141,455.

	Horses and Mules.	Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.
1881	13,988	2124	77,008	8,970	21,288	9,250	396,256
1891	14,969	2459	88,524	25,216	21,442	10,536	470,678
1895	15,367	2352	86,337	18,674	27,957	9,216	540,099
1899	14,001	2394	88,743	21,098	26,960	8,580	616,914

The number of milch cows in 1891 was 31,311, and in 1899, 30,848. It is estimated that the total value of cattle, sheep, and pigs in 1899 was £1,158,077. In 1899 the number of holdings not exceeding 1 acre was 1690; between 1 and 5, 8735; between 5 and 15, 8355; between 15 and 30, 4334; between 30 and 50, 1401; between 50 and 100, 532; between 100 and 200, 95; between 200 and 500, 20; and above 500, only 1—total 20,163. The number of loans issued (the number of tenants being the same as the number of loans) under the Land Purchase Acts, 1885, 1891, and 1896, up to 31st March 1900, was 1360, amounting to £337,101. The number of loans sanctioned for agricultural improvements under sect. 31 of the Land Act, 1881, between 1882 and 1900 was 99, and the amount issued, £5203, the smallest amount issued in any Irish county. The total amount issued on loan for all classes of works under the Land Improvement Acts from the commencement of operations to 31st March 1900 was £22,363, also the smallest amount issued in any Irish county. (W. H. Po.)

Armagh, a city in the above county, 64 miles N. of Dublin, and 30 S.W. of Belfast by rail. It ceased to be a parliamentary borough in 1885. The corporation was abolished in 1841, and the administration since 1898 has been in the hands of an urban district council. The Callan, which flows into the Blackwater, passes near the town, and the Ulster Canal is within 4 miles. There are frequent markets and a fair once a month. Population (1881), 10,070; (1891), 7438; (1901), 7569.

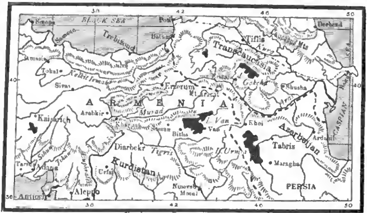
Armavir. Two places of this name must be mentioned. (1) The ruins of the old capital of Armenia, on the S.E. slope of the extinct volcano Ala-ghoz, built by Armais, a grandson of Haik, in 1980 B.C. and the capital of the Armenian kings till the 2nd century A.D. Now a small village, Tapadibi, occupies its seat. (2) A district town of Russia, Northern Caucasia, province of Kuban, on Kuban river, and on the main line of the Caucasian Railway, 40 miles by rail west of Stavropol, built in 1848 for the settlement of Armenian mountaineers, and now a well-built, growing town with 8000 inhabitants, the merchants of which carry on a lively trade.

Armenia (old Persian *Armina*, Armenian *Hayasdan*, or *Haikh*) is the popular name of a district south of the Caucasus and Black Sea, which formed part of the old Armenian kingdom. The name, which first occurs in the cuneiform inscriptions of Darius Hystaspis, supplanted the earlier Urardhu, or Ararat, but its origin is unknown. In its widest extent Armenia stretched from 37° to 49° E. longitude, and from 37½° to 41½° N. latitude; but this area was never, or only for a brief period, united under one king. Armenia is now divided between Persia, Russia, and Turkey, and the three boundaries have a common point on Little Ararat.

Geographically, Armenia is a continuation westward of the great Iranian plateau. On the north it descends abruptly to the Black Sea; on the south it breaks down in rugged terraces to the lowlands of Mesopotamia; and on the east and west it sinks more gradually to the lower plateaux of Persia and Asia Minor. Above the general level of the plateau, 6000 feet, rise bare ranges of mountains, which run from north-east to south-west at an altitude of 8000-12,000 feet, and culminate in Ararat, 17,100 feet. Between the ranges are broad elevated valleys, through which the rivers of the plateau flow before entering the rugged gorges that convey their waters to lower levels. Geologically, Armenia consists of archaic rocks upon which, towards the north, are superimposed Palæozoic, and towards the south later sedimentary rocks. The last have been pierced by volcanic outbursts that extend southward to Lake Van. Amongst the higher mountains are the two Ararats; Ala-geuz Dagh, north of the Aras; Bingeul Dagh, south of Erzerúm; and the peaks near Lake Van. The rivers are the Euphrates, Tigris, Aras, Choruk Su, and Kelkit Irmak, all rising on the plateau. The more important lakes are Van, 5100 feet, about twice the size of the Lake of Geneva, and Urmia, 4000 feet, both salt; Gokcha or Sevan, 5870 feet, discharging into the Aras; and Chaldir, into the Kars Chai. The aspect of the plateau is dreary and monotonous. The valleys are wide expanses of arable land, and the hills are for the most part grass-covered and treeless. But the gorges of the Euphrates and Tigris, and their tributaries, cannot be surpassed in wildness and grandeur. The climate is varied. In the higher districts the winter is long and the cold severe; whilst the summer is short, dry, and hot. In Erzerúm the temperature ranges from − 22° to 84° F., and snow sometimes falls in June. In the valley of the Aras, and in the western and southern districts, the climate is more moderate. Most of the towns lie high, from 4000 to 6000 feet. The villages are usually built on gentle slopes, in which the houses are partially excavated as a protection against the severity of the weather. Many of the early towns were on or near the Araxes, and amongst their ruins are the remains of churches which throw light on the history of Christian architecture in the east. Armenia is rich in mineral wealth, and there are many hot and cold mineral springs. The vegetation varies according to the locality. Cereals and hardy fruits grow on the higher ground, whilst rice is cultivated in the hot, well-watered valley of the Araxes. The summer is so hot that the vine grows at much higher altitudes than it does in Western Europe, and the cotton tree and all southern fruit trees are cultivated in the deeper valleys. On the fine pasture lands which now support the flocks of the Kúrds, the horses and mules, so celebrated in ancient times, were reared. Trout are found in the rivers, and a small herring in Lake Van.

Population.—Accurate statistics cannot be obtained; but it is estimated that in the nine vilâyets, which include Turkish Armenia, there are 925,000 Gregorian, Roman Catholic, and Protestant Armenians, 645,000 other Christians, 100,000 Jews, Gypsies, &c., and 4,460,000 Moslems. The Armenians, taking the most favourable estimate, are in a majority in nine kazas or sub-districts only (seven near Van, and two near Músh) out of 159. In Russian Armenia there are 960,000 Armenians, and in Persian Armenia 130,000. According to an estimate made by General Zelenyi for the Caucasus Geographical Society (*Zapiski*, vol. xviii., Tiflis, 1896, with map), the population of the nine Turkish vilâyets, Erzerúm, Van, Bitlis, Kharpút, Diarbekr, Sivas, Aleppo, Adana, and Trebizond, was 6,000,000 (Armenians, 913,875, or 15 per cent; other Christians, 632,875, or 11 per cent; and Moslems, 4,453,250, or 74 per cent). In the first five vilâyets, which contain most of the Armenians, the population was 2,642,000 (Armenians, 633,250, or 24 per cent; other Christians, 179,875, or 7 per cent; and Moslems, 1,828,875, or 69 per cent); and in the seven Armenian kazas the population was 282,375 (Armenians, 184,875, or 65 per cent; other Christians, 1000, or 0·3 per cent; and Moslems, 96,500, or 34·7 per cent). In 1897 there were 970,656 Armenians in Russia, of whom 827,634 were living in the provinces of Erivan, Elizabethpol, and Tiflis.

History.—The history of Armenia has been largely influenced by its physical features. The isolation of the valleys, especially in winter, encouraged a tendency to separation, which invariably showed itself when the central power was weak. The rugged mountains have always been the home of hardy mountaineers impatient of control, and the sanctuary to which the lowlanders fled for safety in times of invasion. The country stands as an open doorway between the east and the west. Through its long valleys run the roads that connect the Iranian plateau with the fertile lands and protected harbours of Asia Minor, and for its possession nations have contended from the remotest past.



B. V Darbishire & O. J. R. Howarth Engl. Miles 100 0 100 200 Oxford, 1901

Sketch Map of Armenia.

The early history of Armenia, more or less mythical, is partly based on traditions of the Biainian kings (see Ararat), and is interwoven with the Bible narrative, of which a knowledge was possibly obtained from captive Jews settled in the country by Assyrian and Babylonian monarchs. The legendary kings are but faint echoes of the kings of Biainas; the story of Semiramis and Ara is but another form of the myth of Venus and Adonis; and tradition has clothed Tigranes, the reputed friend of Cyrus, with the transient glory of the opponent of Lucullus. The fall of the Biainian kingdom, perhaps overthrown by Cyaxares, was apparently soon followed by an immigration of Aryan (Medo-Persian) races, including the progenitors of the Armenians. But they spread slowly, for the "Ten Thousand," when crossing the plateau to Trebizond, 401-400 B.C., met no Armenians after leaving the villages four days' march beyond the Teleboas, now Kara Su. Under the Medes and Persians Armenia was a satrapy governed by a member of the reigning family; and after the battle of Arbela, 331 B.C., it was ruled by Persian governors appointed by Alexander and his successors. Ardvates, 317-284 B.C., freed himself from Seleucid control;

Ancient history.

and after the defeat of Antiochus the Great by the Romans, 190 B.C., Artaxias (Ardashes), and Zadriades, the governors of Armenia Major and Armenia Minor, became independent kings, with the concurrence of Rome. Artaxias established his capital at Artaxata on the Araxes, and his most celebrated successor was Tigranes (Dikran), 94-56 B.C., the son-in-law of Mithradates. Tigranes founded a new capital, Tigranocerta, in Northern Mesopotamia, which he modelled on Nineveh and Babylon, and peopled with Greek and other captives. Here, and at Antioch, he played the part of "great-king" in Asia until his refusal to surrender his father-in-law involved him in war with Rome. Defeated, 69 B.C., by Lucullus beneath the walls of his capital, he surrendered his conquests to Pompey, 66 B.C., who had driven Mithradates across the Phasis, and was permitted to hold Armenia as a vassal state of Rome. The campaigns of Lucullus and Pompey brought Rome into delicate relations with Parthia. Armenia, although politically dependent upon Rome, was connected with Parthia by geographical position, a common language and faith, intermarriage, and similarity of arms and dress. It had never been Hellenized, as the provinces of Asia Minor had been; the Roman provincial system was never applied to it; and the policy of Rome towards it was never consistent. The country became the field upon which the East and the West contended for mastery, and the struggle ended for a time in the partition of Armenia, A.D. 387, between Rome and Persia. The Roman portion was soon added to the Diocesis Pontica. The Persian portion, Pers-Armenia, remained a vassal state under an Arsacid prince until 428. It was afterwards governed by Persian and Armenian noblemen selected by the "great-king," and entitled *marzbans*. Before the partition, Tiridates, converted by St. Gregory, "the Illuminator," had established Christianity as the religion of the state, and set an example followed later by Constantine. After the partition, the invention of the Armenian alphabet, and the translation of the Bible into the vernacular, 410, drew the Armenians together, and the discontinuance of Greek in the Holy Offices relaxed the ecclesiastical dependence on Constantinople, which ceased entirely when the Patriarch, 491, refused to accept the decrees of the Council of Chalcedon. The rule of the *marzbans* was marked by relentless persecution of the Christians, forced conversions to Magism, frequent insurrections, and the rise to importance of the great families founded by men of Assyrian, Parthian, Persian, Syrian, and Jewish origin, and in some cases of royal blood, who had been governors of districts, or holders of fiefs under the Arsacids. Amongst the *marzbans* were Jewish Bagratids and Persian Mamegonians; and one of the latter family, Vartan, made himself independent (571-578), with Byzantine aid. In 632 the victories of Heraclius restored Armenia to the Byzantines; but the war that followed the Arab invasion, 636, left the country in the hands of the khalifs, who set over it Arab and Armenian governors (*ostikans*). One of the governors, the Bagratid Ashod I., was crowned king of Armenia by the khalif Mutamid, 885, and founded a dynasty which ended with Kagig II. in 1079. A little later the Ardzrunian Kagig, governor of Vaspuragan or Van, was crowned king of that province by the khalif Muktadir, 908, and his descendants ruled at Van and Sivas until 1080. The Bagratids founded dynasties at Kars, 962-1080, and in Georgia, which they held until its absorption, 1801, by Russia. From 984 to 1085 the country from Diarbekr to Melasgerd was ruled, under the suzerainty first of Arabs, then of Byzantines and Seljúks, by the Mervanid dynasty of Kúrds, called princes of Abahuni ('Απαχουνῆς). The Arab invasion drove many Armenian noblemen to Constantinople, where they inter-married with the old Roman families or became soldiers of fortune. Artavasdes, an Arsacid, usurped the Byzantine throne for two years; Leo V., an Ardzrunian, and John Zimiskes, became emperors; whilst Manuel, the Mamegonian, and others were amongst the best generals of the empire. In 991, and again in 1021, Basil II. invaded Armenia, and in the latter year Senekherim, king of Vaspuragan, exchanged his kingdom for Sivas and its territory, where he settled down with many Armenian emigrants. Basil's policy was to make the great Armenian fortresses, garrisoned by imperial troops, the first line of defence on his eastern frontier; but it failed in the hands of his feeble successors, who thought more of converting heretical Armenia than of defending its frontier. The king of Ani, Kagig II., was compelled to exchange his kingdom for estates in Cappadocia. The country was raided by Seljúks and harried by Byzantine soldiers, and the miseries of the people were regarded as gain to the Orthodox church. After the defeat and capture of Romanus IV. by Alp Arslan, 1071, Armenia formed part of the Seljúk empire until it split up, 1157, into petty states, ruled by Arabs, Kúrds, and Seljúks, who were in turn swept away by the Mongol invasion, 1235. For more than three centuries after the appearance of the Seljúks, Armenia was traversed by a long succession of nomad tribes whose one aim was to secure good pasturage for their flocks on their way to the richer lands of Asia Minor. The cultivators were driven from the plains, agriculture was destroyed, and the country was seriously impoverished when its ruin was completed by the ravages and wholesale butcheries of Timúr. Many Armenians fled to the mountains where they embraced Islám, and intermarried with the Kúrds, or purchased security by paying blackmail to Kúrdish chiefs. Others migrated to Cappadocia or to Cilicia, where the Bagratid Rhupen had founded, 1080, a small principality which, gradually extending its limits, became the kingdom of Lesser Armenia. This Christian kingdom in the midst of Moslem states, hostile to the Byzantines, giving valuable support to the leaders of the Crusades, and trading with the great commercial cities of Italy, had a stormy existence of about 300 years. Internal disorders, due to attempts by the later Lusignan kings, to make their subjects conform to the Roman Church, facilitated its conquest by Egypt, 1375. The memory of Kiligia (Cilicia) is enshrined in a popular song, and at Zeitún, in the recesses of Mount Taurus, a small Armenian community has hitherto maintained almost complete independence. After the death of Timúr, Armenia formed part of the territories of the Turkoman dynasties of Ak- and Kara-Koyunlu, and under their milder rule the seat of the Katholikos, which, during the Seljúk invasion, had been moved first to Sivas, and then to Lesser Armenia, was re-established, 1441, at Echmiadzin.

Modern times.

In 1514, the Persian campaign of Selim I. gave Armenia to the Osmanli Turks, and its reorganization was entrusted to Idris, the historian, who was a Kúrd of Bitlis. Idris found the rich arable lands almost deserted, and the mountains bristling with the castles of independent chieftains, of Kúrd, Arab, and Armenian descent, between whom there were long-standing feuds. He compelled the Kúrds to settle on the vacant lands, and divided the country into small sanjaks which in the plains were governed by Turkish officials, and in the mountains by local chiefs. This policy gave rest to the country, but favoured the growth of Kúrd influence and power, which by 1534 had spread westwards to Angora. Armenia was invaded by the Persians in 1575, and again in 1604, when Shah Abbas transplanted many thousand Armenians from Julfa to his new capital

Isfahán. In 1639, the province of Erivan, which included Echmiadzin, was assigned by treaty to Persia, and it remained in her hands until it passed to Russia, 1828, under the treaty of Turkman-chai. The Turko-Russian war of 1828-29, which advanced the Russian frontier to the Arpa Chai, was followed by a large emigration of Armenians from Turkish to Russian territory, and a smaller exodus took place after the war of 1877-78, which gave Batúm, Ardahan, and Kars to Russia. In 1834 the independent power of the Kúrds in Armenia was greatly curtailed; and risings under Bedr Khan Bey in 1843, and Sheikh Obeidullah in 1880, were firmly suppressed.

Gregorian Armenians.—After the capture of Constantinople, 1453, Muhammad II. organized his non-Moslem subjects in communities, or *millets*, under ecclesiastical chiefs to whom he gave absolute authority in civil and religious matters, and in criminal offences that did not come under the Moslem religious law. Under this system the Armenian bishop of Brúsa, who was appointed patriarch of Constantinople by the Sultan, became the civil, and practically the ecclesiastical head of his community (*Ermeni millet*), and a recognized officer of the Imperial Government with the rank of vizier. He was assisted by a council of bishops and clergy, and was represented in each province by a bishop. This *imperium in imperio* secured to the Armenians a recognized position before the law, the free enjoyment of their religion, the possession of their churches and monasteries, and the right to educate their children and manage their municipal affairs. It also encouraged the growth of a community life, which eventually gave birth to an intense longing for national life. On the other hand it degraded the priesthood. The priests became political leaders rather than spiritual guides, and sought promotion by bribery and intrigue. Education was neglected and discouraged, servility and treachery were developed, and in less than a century the people had become depraved and degraded to an almost incredible extent. After the issue, 1839, of the Hatt-i-Sherif of Gul-khaneh, the tradesmen and artisans of the capital freed themselves from clerical control. Under regulations, approved by the Sultan in 1862, the patriarch remains the official representative of the community, but all real power has passed into the hands of clerical and lay councils elected by a representative assembly of 140 members. The "community," which excluded Roman Catholics and Protestants, was soon called the "nation," "domestic" became "national" affairs, and the "representative" the "national" assembly.

Roman Catholics.—The connexion of "Lesser Armenia" with the Western Powers led to the formation, 1335, of an Armenian fraternity, "the Unionists," which adopted the dogmas of the Roman church, and at the council of Florence, 1439, was entitled the "United Armenian Church." Under the millet system the unionists were frequently persecuted by the patriarchs, but this ended in 1830, when, at the intervention of France, they were made a community (*Katolik millet*), with their own ecclesiastical head. The Roman Catholics, through the works issued by the Mekhitarists at Venice, have greatly promoted the progress of education and the development of Armenian literature. They are most numerous at Constantinople, Angora, and Smyrna.

Protestants.—The Protestant movement, initiated, 1831, at Constantinople by American missionaries, was opposed by the patriarchs and Russia. In 1846 the patriarch anathematized all Armenians with Protestant sympathies, and this led to the formation of the "Evangelical Church of the Armenians," which was made, after much opposition from France and Russia, a community (*Protestant millet*), at the instance of the British ambassador. The missionaries afterwards founded colleges on the Bosporus, at Kharpút, Marsivan, and Aintab, to supply the needs of higher university education, and they opened good schools for both sexes at all their stations. Everywhere they supplied the people with pure, wholesome literature, and represented progress and religious liberty.

Recent events.

When Abdul Hamid came to the throne, 1876, the condition of the Armenians was better than it had ever been under the Osmanlis; but with the close of the war of 1877-78 came the "Armenian Question." By the Treaty of San Stefano, Turkey engaged to Russia to carry out reforms "in the provinces inhabited by the Armenians, and to guarantee their security against the Kúrds and Circassians." By the Treaty of Berlin, 13th July 1878, a like engagement to the six signatory Powers was substituted for that to Russia. By the Cyprus Convention, 4th June 1878, the Sultan promised Great Britain to introduce necessary reforms "for the protection of the Christians and other subjects of the Porte" in the Turkish territories in Asia. The Berlin Treaty encouraged the Armenians to look to the Powers, and not to Russia for protection; and the Convention, which did not mention the Armenians, was regarded as placing them under the special protection of Great Britain. This impression was strengthened by the action of England at Berlin in insisting that Russia should evacuate the occupied territory before reforms were introduced, and so removing the only security for their introduction. The presentation of identic and collective notes to the Porte by the Powers, in 1880, produced no result, and in 1882 it was apparent that Turkey would only yield to compulsion. In 1881 a circular note from the British Ministry to the five Powers was evasively answered, and in 1883 Prince Bismarck intimated to the British Government that Germany cared nothing abont Armenian reforms and that the matter had better be allowed to drop. Russia had changed her policy towards the Armenians, and the other Powers were indifferent. The so-called "Concert of Europe" was at an end, but down to 1894 British ministries called the attention of the Sultan to his obligations under the Berlin Treaty.

Russian policy.

Russia began to interest herself in the Armenians when she acquired Georgia in 1801; but it was not until 1828-29 that any appreciable number of them became her subjects. She found them necessary to the development of her new territories, and allowed them much freedom. They were permitted, within certain limits, to develop their national life; many became wealthy, and many rose to high positions in the military and civil service of the state. After the war of 1877-78 the Russian Consuls in Turkey encouraged the formation of patriotic committees in Armenia, and a project was formed to create a separate state, under the supremacy of Russia, which was to include Russian, Persian, and Turkish Armenia. The project was favoured by Loris Melikof, then all-powerful in Russia, but in 1881 Alexander II. was assassinated and shortly afterwards a strongly anti-Armenian policy was adopted. The schools were closed, the use of the Armenian language was discouraged, and attempts were made to Russify the Armenians and bring them within the pale of the Russian Church. All hope of practical self-government under Russian protection now ceased, and the Armenians of Tiflis turned their attention to Turkish Armenia. They had seen the success of the Sclav committees in creating disturbances in the Balkans, and became the moving spirit in the attempts to produce similar troubles in Armenia. Russia made no real effort to check the action of her Armenian subjects, and since 1884 she has steadily opposed any active interference by Great Britain in favour of the Turkish Armenians. When

Echmiadzin passed to Russia, in 1828, the Katholikos began to claim spiritual jurisdiction over the whole Armenian Church, and the submission of the patriarch of Constantinople was obtained by Russia when she helped Turkey in her war with Egypt. Recently Russia has secured the submission of the independent Katholikos of Sis, and has thus acquired a power of interference in Armenian affairs in all parts of the world. During 1900 Russia showed renewed interest in Turkish Armenia by securing the right to construct all railways in it, and in the Armenians by pressing the Porte to restore order and introduce reforms.

Revolutionary movement.

The Berlin Treaty was a disappointment to the Gregorian Armenians, who had hoped that Armenia and Cilicia would have been formed into an autonomous province administered by Christians. But the formation of such a province was impossible. The Gregorians were scattered over the empire, and, except in a few small districts, were nowhere in a majority. Nor were they bound together by any community of thought or sentiment. The Turkish-speaking Armenians of the south could scarcely converse with the Armenian-speaking people of the north; and the ignorant mountaineers of the east had nothing in common, except religion, with the highly-educated townsmen of Constantinople and Smyrna. After the change in Russian policy and the failure of the Powers to secure reforms, the advanced party amongst the Armenians, some of whom had been educated in Europe and been deeply affected by the free thought and Nihilistic tendencies of the day, determined to secure their object by the production of disturbances such as those that had given birth to Bulgaria. Societies were formed at Tiflis and in several European capitals for the circulation of pamphlets and newspapers, and secret societies, such as the Huntchagist, were instituted for more revolutionary methods. An active propaganda was carried on in Turkish Armenia by emissaries, who tried to introduce arms and explosives, and represented the ordinary incidents of Turkish misrule to Europe as serious atrocities. The revolutionary movement was joined by some of the younger men, who formed local committees on the Nihilist plan, but it was strongly opposed by the Armenian clergy and the American missionaries, who saw the impossibility of success; and its irreligious tendency and the self-seeking ambition of its leaders made it unacceptable to the mass of the people. Exasperated at their failure, the emissaries organized attacks on individuals, wrote threatening letters, and at last posted revolutionary placards, 5th January 1893, at Yuzgat, and on the walls of the American College at Marsivan. In the last case the object of the Huntchagists was to compromise the missionaries, and in this they succeeded. The Americans were accused of issuing the placards; two Armenian professors were imprisoned; and the girls' school was burned down. Outbreaks, that were easily suppressed, followed at Kaisarieh and other places.

One of the revolutionary dreams was to make the ancient Daron the centre of a new Armenia. But the movement met with no encouragement, either amongst the prosperous peasants on the rich plain of Músh or in the mountain villages of Sasún. In the summer of 1893, an emissary was captured near Músh, and the governor, hoping to secure others, ordered the Kúrdish Irregular Horse to raid the mountain district. The Armenians drove off the Kúrds,[1] and, when attacked in the spring of 1894, again held their own. The Vali now called up regular troops from Erzingan; and the Sultan issued a firman calling upon all loyal subjects to aid in suppressing the revolt. A massacre of a most brutal character, in which Turkish soldiers took part, followed; and aroused deep indignation in Europe. In November 1894 a Turkish commission of inquiry was sent to Armenia, and was accompanied by the Consular delegates of Great Britain, France, and Russia, who elicited the fact that there had been no attempt at revolt to justify the action of the authorities. Throughout 1894 the state of the country bordered upon anarchy, and during the winter of 1894-95 the British Government, with lukewarm support from France and Russia, pressed for administrative reforms in the viláyets of Erzerúm, Van, Bitlis, Sivas, Memuret-el-Aziz (Kharpút), and Diarbekr. The Porte made counter-proposals, and officials concerned in the Sasún massacres were decorated and rewarded. On 11th May 1895 the three Powers presented to the Sultan a complicated scheme of reforms which was more calculated to increase than to lessen the difficulties connected with the government of Armenia; but it was the only one to which Russia would agree. The Sultan delayed his answer. Great Britain was in favour of coercion, but Russia when sounded, replied that she "would certainly not join in any coercive measures" and she was supported by France. At this moment, 21st June 1895, Lord Rosebery's Cabinet resigned, and when Lord Salisbury's Government resumed the negotiations in August, the Sultan appealed to France and Russia against England. During the negotiations the secret societies had not been inactive. Disturbances occurred at Tarsus; Armenians who did not espouse the "national" cause were murdered; the life of the patriarch was threatened; and a report was circulated that the British ambassador wished some Armenians killed to give him an excuse for bringing the fleet to Constantinople. On the 1st October 1895 a number of Armenians, some armed, went in procession with a petition to the Porte and were ordered by the police to disperse. Shots were fired, and a riot occurred in which many Armenian and some Moslem lives were lost. The British ambassador now pressed the scheme of reforms upon the Sultan, who accepted it on the 17th October. Meanwhile there had been a massacre at Trebizond (8th October), in which armed men from Constantinople took part, and it had become evident that no united action on the part of the Powers was to be feared. The Sultan refused to publish the scheme of reforms, and massacre followed massacre in Armenia in quick succession until 1st January 1896. Nothing was done. Russia refused to agree to any measure of coercion, and declared (19th December) that she would take no action except such as was needed for the protection of foreigners. Great Britain was not prepared to act alone. In the summer of 1896 (14th-22nd June) there were massacres at Van, Egin, and Niksar; and on the 26th August the Imperial Ottoman Bank at Constantinople was seized by revolutionists as a demonstration against the Christian Powers who had left the Armenians to their fate. The project was known to the Porte, and the rabble, previously armed and instructed, were at once turned loose in the streets. Two days' massacre followed, during which from 6000 to 7000 Gregorian Armenians perished. Soon afterwards the attention of the Turkish Government was fully occupied by the course of events in Crete.

The massacres were apparently organized and carried out in accordance with a well-considered plan. They

---

[1] The Armenians and Kúrds have lived together from the earliest times. The adoption of Islám by the latter, and by many Armenians, divided the people sharply into Christian and Moslem, and placed the Christian in a position of inferiority. But the relations between the two sects were not unfriendly previously to the Russian campaigns in Persia and Turkey. After 1829, the relations became less friendly; and later, when the Armenians attracted the sympathies of the European Powers after the war of 1877-78 they became bitterly hostile.

The massacres.

occurred, except in six places, in the vilâyets to which the scheme of reforms was to apply. At Trebizond they took place just before the Sultan accepted that scheme, and after his acceptance of it they spread rapidly. They were confined to Gregorian and Protestant Armenians. The Roman Catholics were protected by France, the Greek Christians by Russia. The massacre of Syrians, Jacobites, and Chaldees at Urfa and elsewhere, formed no part of the original plan. Orders were given to protect foreigners, and in some cases guards were placed over their houses. The damage to the American buildings at Kharpút was due to direct disobedience of orders. The attacks on the bazárs were made without warning, during business hours, when the men were in their shops and the women in their houses. Explicit promises were given, in some instances, that there would be no danger to those who opened their shops, but they were deliberately broken. Nearly all those who, from their wealth, education, and influence, would have had a share in the government under the scheme of reforms, were killed and their families ruined by the destruction of their property. Where any attempt at defence was made the slaughter was greatest. The only successful resistance was at Zeitún, where the people received honourable terms after three months' fighting. In some towns the troops and police took an active part in the massacres. At Kharpút artillery was used. In some the slaughter commenced and ended by bugle-call, and in a few instances the Armenians were disarmed beforehand. Wherever a superior official or army officer intervened the massacre at once ceased, and wherever a governor stood firm there was no disturbance. The actual perpetrators of the massacres were the local Moslems, aided by Lazis, Kúrds, and Circassians. A large majority of the Moslems disapproved of the massacres, and many Armenians were saved by Moslem friends. But the lower orders were excited by reports that the Armenians, supported by the European Powers, were plotting the overthrow of the Sultan; and their cupidity was aroused by the prospect of wiping out their heavy debts to Armenian pedlars and merchants. No one was punished for the massacres, and many of those implicated in them were rewarded. In some districts, especially in the Kharpút vilâyet, the cry of "Islám or death" was raised. Gregorian priests and Protestant pastors were tortured, but preferred death to apostasy. Men and women were killed in prison and in churches in cold blood. Churches, monasteries, schools, and houses were plundered and destroyed. In some places there was evidence of the previous activity of secret societies, in others none. The number of those who perished, excluding Constantinople, was 20,000 to 25,000.[1] Many were forced to embrace Islám, and numbers were reduced to poverty. The destruction of property was enormous, the hardest-working and best tax-paying element in the country was destroyed, or impoverished, and where the bread-winners were killed the women and children were left destitute. Efforts by Great Britain and the United States to alleviate the distress were opposed by the authorities, but met with some success. Since the massacres the number of students in the American schools and colleges has increased, and many Gregorian Armenians have become Roman Catholics in order to obtain the protection of France.

Ethnology.—The original inhabitants of Armenia are unknown, but, about the middle of the 9th century B.C., the mass of the people belonged to that great family of tribes which seems to have been spread over Western Asia and to have had a common non-Aryan language. Mixed with these proto-Armenians, there was an important Semitic element of Assyrian and Hebrew origin. In the 7th century B.C., between 640 and 600, the country was conquered by an Aryan people, who imposed their language and possibly their name, upon the vanquished, and formed a military aristocracy that was constantly recruited from Persia and Parthia. Politically the two races soon amalgamated, but except in the towns, there was apparently little intermarriage, for the peasants in certain districts closely resemble the proto-Armenians, as depicted on their monuments. After the Arab and Seljúk invasions, there was a large emigration of Aryan and Semitic Armenians to Constantinople and Cilicia; and all that remained of the aristocracy was swept away by the Mongols and Tatars. This perhaps explains the diversity of type and characteristics amongst the modern Armenians. In the recesses of Mount Taurus the peasants are tall, handsome, though somewhat sharp-featured, agile, and brave. In Armenia and Asia Minor they are robust, thick-set, and coarse-featured, with straight black hair and large hooked noses. They are good cultivators of the soil, but are poor, superstitious, ignorant, and unambitious, and they live in semi-subterranean houses as their ancestors did 800 years B.C. The townsmen, especially in the large towns, have more regular features—often of the Persian type. They are skilled artisans, bankers, and merchants, and are remarkable for their industry, their quick intelligence, their aptitude for business, and for that enterprising spirit which led their ancestors, in Roman times, to trade with Scythia, China, and India. The upper classes are polished and well educated, and many have occupied high positions in the public service in Turkey, Russia, Persia, and Egypt. The Armenians are essentially an Oriental people, possessing, like the Jews, whom they resemble in their exclusiveness and widespread dispersion, a remarkable tenacity of race and faculty of adaptation to circumstances. They are frugal, sober, industrious, and intelligent, and their sturdiness of character has enabled them to preserve their nationality and religion under the sorest trials. They are strongly attached to old manners and customs, but have also a real desire for progress which is full of promise. On the other hand they are greedy of gain, quarrelsome in small matters, self-seeking, and wanting in stability; and they are gifted with a tendency to exaggeration and a love of intrigue which has had an unfortunate influence on their history. They are deeply separated by religious differences, and their mutual jealousies, their inordinate vanity, their versatility, and their cosmopolitan character must always be an obstacle to the realization of the dreams of the nationalists. The want of courage and self-reliance, the deficiency in truth and honesty sometimes noticed in connexion with them, are doubtless due to long servitude under an unsympathetic Government.

The total number of Armenians is estimated at 2,900,000 (in Turkey, 1,500,000; Russia, 1,000,000; Persia, 150,000; Europe, America, and East Indies, 250,000).

See Abich. *Geologie d. armenischen Hochlandes.* Wien, 1882.—Bishop. *Journeys in Persia and Kurdistan.* Lond., 1891.—Bliss. *Turkey and the Armenian Atrocities.* Lond., 1896.—Bryce. *Transcaucasia and Ararat*, 4th ed. Lond., 1896.—Da Coursons. *La rébellion arménienne.* Paris, 1895.—Lepsius. *Armenia and Europe.* Lond., 1897.—Murray. *Handbook for Asia Minor.* Lond., 1895.—Parly. Papers. *Turkey*, I., 1895; *Turkey*, I., II., 1896.—Supan. "Die Verbreitung d. Armenier in der asiatischen Turkei, u. in Transkaukasien," in Pet. *Mitth.* vol. xlii., 1896.—Tozer. *Turkish Armenia and Eastern Asia Minor*, Lond., 1881.—Cholet. *Arménie, Kurdistan, et Mésopotamie*, 1892.—Lynch. *Armenia.* 2 vols. 1901. (C. W. W.)

---

[1] According to some estimates the number killed was 50,000 or more.

Armentières, a town of France, department of Nord, arrondissement of Lille, 10 miles W.N.W. of that town, on the railway from Lille to Dunkirk. It has a communal college for boys and one for girls, a national professional school, hospital, museum, and small library. It is an important centre of textile manufactures. Population (1896), 26,714; (1901), 29,401.

ARMIES.

Introductory.

The last quarter of the 19th century saw a great development of military forces, but no organic changes. Armies have steadily grown in size, and the severe competition for predominance in numbers has led to reductions in the period of service with the colours. At the same time the principle of universal liability to service has been rigorously enforced by all the great powers of Europe. Relatively to that of France the population of Germany has been steadily increasing, and the former country, unless the period of service is still further curtailed, must soon find its army considerably inferior in numerical strength to that of the latter. Whether or not such further reduction is compatible with military efficiency appears to be doubtful. The tendency of modern war is to increase the demand for careful training of all ranks, and two years of continuous military life is barely sufficient to make the average man into a thoroughly competent infantry soldier, while the technical branches of an army cannot be adequately instructed in so short a time. Systems of national education, by developing the receptivity of the recruit and sharpening his faculties, have undoubtedly facilitated military training; but habits of discipline, the mutual reliance and mutual knowledge of officers and men, and the many qualities necessary to the making of effective military bodies, need time for their development. While, therefore, the standard of general intelligence of a population, other national characteristics being equal, may to some extent regulate the period of service necessary to ensure military efficiency, there is evidently a *minimum* in every case which cannot be passed without danger. The relatively low intelligence of the Russian population would probably render it impossible to transform the recruit into a trained soldier in two years, and in the Russian army, as in the British, the period is long, compared with that accepted in other great European forces. What the irreducible *minimum* is in any particular case cannot at present be stated. There have been signs that the short-service system does not confer the solidarity which existed in the older professional armies. The Franco-German war produced an almost unbroken series of successes for the German arms. The sense of military superiority conferred by the early victories on the frontier and maintained by subsequent experience was a moral factor of supreme importance. The system brought to perfection by the Germans cannot, however, be said to have been tested by defeat, and there were ugly symptoms of panic during the fighting around Metz, which, in less favourable circumstances, might have spread with disastrous results. Since this war, the period of service has been reduced in both Germany and France; and while in both countries careful consideration has been given to all that is implied in the term organization, and the military machine, as such, has therefore gained greatly in efficiency, the result, as affecting the solidarity of a great army in the field, remains to be shown. Where the constitution of two armies is practically the same, and where numbers and military skill are practically equal, the issue of a contest would turn upon the characteristics of the race or of the nation. On the other hand, it is possible that an army more solidly constructed than those of modern Europe might be found to possess qualities of cohesion and of endurance which would, to a great extent, compensate for numerical deficiency. It can only be said with certainty that modern war makes increasing demands upon military training in every branch, enhances the value of individual military capacity, and imposes more and more strain upon the nerve and endurance of the soldier. At the same time, the race for numerical strength increases the difficulty of obtaining the necessary qualities without an inordinate growth of military expenditure and a consequent dislocation of the machinery of civil life entailed when masses of men are called up for periodical training. The problem of the future is to effect a satisfactory compromise between these conflicting conditions.

Military systems practically fall into two categories—the short-service, or German system, which is universal among great European powers, and which has now extended to Japan; and the militia system, which in England dates back to Saxon times, and which has reached its most complete development in Switzerland. The first system aims at sweeping the mass of the able-bodied manhood of a nation into the ranks for a short period of continuous training, followed by a long period of furlough and a further period of liability to service in a national reserve. During the period of furlough the soldier may be recalled from time to time to the colours for instruction. The militia system, on the other hand, imposes an initial training of six or eight weeks, followed by a general annual training of the whole force for a fixed period during several years, and by a further period in a national reserve. It is evident that, if the period of service with the colours in the first system is steadily reduced, there must come a point at which the second system may provide the best means of military training. This point may not have been yet reached; but some authorities, watching present tendencies, have been led to believe that the militia system may ultimately supersede that devised by Scharnhorst, with the powerful support of Stein, for the military regeneration of Prussia after the disasters of 1806.

The experience of recent years has gone far to modify the view, cherished in Great Britain, that universal service is destructive of the industrial vigour of a nation. Under a rigid system, relentlessly applied, Germany has presented the spectacle of an amazing commercial development. It has even been contended that the habits of order, of discipline, and of self-reliance inculcated by military training, wisely administered, have played a part in equipping the German people for the industrial competition upon which they have entered with the most marked success. In face of facts which cannot be disputed, it will be difficult in future to maintain that the burden of compulsory military service necessarily impedes the industrial progress of a nation and breaks up its civil organization. The management of public business in Germany and the handling of great questions of national defence stand in marked contrast to British methods. Military training, as enforced upon the best manhood of Germany, has not benumbed its intellectual vigour, and may have increased its capacity for the orderly transaction of business. Personal service is a higher test of patriotism than pecuniary contributions, and it is not easy to determine which of the two imposes the greater drain upon national resources. The British nation must shortly decide between compulsion and greatly-increased expenditure; and while an army habitually required to serve abroad in peace time cannot be recruited by conscription in any form, there is a growing tendency to believe that the application of the ballot for recruiting a militia army may be justified. The past twenty-five years have witnessed the results of organic changes in the British army which began in 1870. It cannot be said that these changes have produced all that was claimed by their advocates or that the criticisms expended upon them were entirely without foundation. The British army has undergone a searching test in the South African war. Grave defects of many kinds have been plainly revealed, and a strong demand for radical reorganization has been the result.

The wars of the past quarter-century have not provided any specially striking military lessons, but all have presented points of interest and have emphasized the vital importance of organized preparation in time of peace. The Russo-Turkish war of 1877-78 illustrated the great defensive power of breech-loading small arms, and showed many tactical defects in the training of the Russian infantry. This war, like the war in South Africa of 1899 and 1900, was entered upon with a totally inadequate idea of the military requirements. In both cases certain disabilities on the part of the opposing forces—whether Turks or Boers—gave time which enabled the initial defeats to be redeemed. In the Servo-Bulgarian war of 1885, the militia army of Servia was opposed to a Bulgarian force organized on the German principles and supplemented by Rumelian militia. This conflict presented the remarkable feature that the whole of the superior officers of the Bulgarian army, being Russians, were suddenly withdrawn on the outbreak of hostilities. To the personal leadership of Prince Alexander, to the soldierly qualities of the Bulgarians, and to the remarkable marching power of the Rumelian militia, the victory over the Servians was directly due. A small-bore rifle in the modern sense was employed for the first time by the Servians, and the Bulgarian field artillery opposed time shrapnel to common shell with notable success. The China-Japan conflict of 1894 revealed in the most striking way the great fighting power of the newly-organized Japanese army and the marked ability with which it had been prepared for war. A new military nation may be said to have come into existence, which must play an important part in the affairs of the Far East. The brief Spanish-American war of 1898 plainly indicated the weakness of volunteer organizations and the heavy cost entailed by want of preparation. The small standing army of the United States was not organized for offensive war; but the excellent quality of the troops averted disaster at Santiago. The Spanish forces in Cuba showed little enterprise or capacity; but local conditions had tended to deteriorate their military qualities, and they did not fairly represent the army of Spain. The principal result of this war was to bring about the over-sea expansion of the United States. This has already entailed a considerable increase in their military forces. The Act of Congress of February 1901 authorizes the President to maintain a standing army of 100,000 men, and to raise local forces in the Philippine Islands. In the Greco-Turkish war, loose discipline, bad leading, and want of organization combined to cause the collapse of the Greek army. The conduct of the campaign by the Turks proved that progress had been attained under German instruction since the conflict with Russia; but certain disabilities, which appear to be inherent in Turkish armies, were again manifested. Great Britain has been engaged in military operations of a varied character in many parts of the world, thus receiving lessons which were not in all cases turned to full account. A long series of minor campaigns, beginning at Alexandria in 1882, ended at Khartûm in 1898. Two considerable wars, in Afghanistan and on the north-west frontier, were carried on by the Government of India. The South African war severely strained British military resources and proved that the standard of preparations had not been adjusted to meet national requirements. No Power has, during the past twenty-five years, acquired experience of warlike operations comparable in extent and variety to that which the British army now has at its disposal. South America has been the scene of several conflicts, of which the Chilian civil war of 1891 was, perhaps, the most important. In this case a military force was organized *ad hoc* by a German expert and equipped with magazine rifles, which were used for the first time on a large scale.

The period, regarded as a whole, has been marked by a great expansion of military forces and by successive and costly re-armaments, both of artillery and infantry. Great attention has been generally devoted to organization and all that is implied in preparation for war. The armies of to-day are larger, better equipped, and more carefully trained than previously; and except in Italy, and possibly in Russia, there are no clear signs that the burdens of military service and of military expenditure are at present pressing with unbearable severity upon the population of Europe. (G. S. C.)

British Army.

Recruiting and conditions of service.

The moment at which the following article was completed (November 1901) was necessarily an exceptional one in the history of the British army. The whole system of administration which was introduced after 1870 had undergone many modifications, and was about to undergo many more.

In its general features, nevertheless, the recruiting system remained that which was introduced by Mr Cardwell in the years following 1870. It was adopted in the belief that a much larger number of recruits could be obtained if they had the option of leaving after a comparatively short period with the colours. It was assumed that after three years' service, at all events in the infantry, a man had learnt all that he was likely to learn, and that it was more economical for the country after that time to pay him for some years a small retaining fee, and call him up only for war. The necessity of sending troops to India and to distant British colonies did not admit of a strict application of this principle to the whole army. Whilst, therefore, the Guards, who do not serve during peace time in distant parts of the empire, and the Army Service Corps, which requires large expansion for war and is not required in India which has its own transport and supply department, have now for a long period been enlisted for three years with the colours and nine years in the Reserve,—the Line, the Artillery, and the Cavalry are mostly enlisted for seven years with the colours and five more in the Reserve. From time to time, however, enlistment for the line for three years has been allowed concurrently with the longer period.

The pay of the soldier has been slightly improved. First he was given in 1876 an allowance known as "deferred pay." A daily addition to his pay of 2d. a day was credited to him in his accounts; but he was not entitled to receive it till he took his discharge. There was a considerable conflict of evidence as to whether the money was valuable to the soldier in enabling him to start in civil life, or whether it was merely wasted. The vast preponderance of the evidence of non-commissioned officers and men was in its favour. There was, however, a strong demand that the soldier should be given not only a free ration of meat and bread, as he had had for many years, but that all his food should be provided for him. The promise of a free ration was said to create the false impression that the men would have nothing to pay for their food, whereas a stoppage was made from their pay to provide groceries. In 1899, therefore, an allowance of 3d. was granted to provide what was absolutely necessary for the whole messing. At the same time the deferred pay ceased for those who accepted the messing allowance. Men serving when the change was made were allowed to choose whether they would prefer the free messing or the deferred pay. Some chose one, some the other. The actual conditions of service in these circumstances are as shown in Table C.

Another change has gradually been introduced. The canteens, which were formerly let out to tenants, and became, in fact, regulated public-houses and grocery shops within the barracks, have been placed under the management of a committee of officers, and are worked for the benefit of the men. Where they are well looked after very large profits accumulate. These are employed partly in adding to the comfort of the men's messes, partly in providing for emergencies, such as when the men are sent out on an early movement and require breakfast before they start, or on the sudden arrival from abroad or from outstations of parties of men or of their families. In various other ways the money is used to provide for contingencies that can hardly be dealt with at the public expense, such as the provision of cricket and football implements.

Private benevolence has added greatly to the comfort of the soldier. Soldiers' "Homes" and "Institutes," set up by private subscription, give an opportunity for well-conducted entertainments and for quiet reading and writing such as would not be possible in the barrack-room. Some of the best of these are, in fact, excellent clubs, with good hot and cold water baths, billiard-rooms, and halls for concert and other performances.

The effect of the short-service system has been necessarily to throw annually upon civil life a very much larger number of men seeking employment than was the case formerly. It was some time before adequate agencies for assisting the men in this respect were brought into existence, but on the whole the machinery is now very complete. Partly through the colonels of brigade districts, partly through the officers of the recruiting department, partly through the organizations which have been established in most well-managed regiments, the men have much help from the army itself in obtaining situations. The "National Society for the Employment of Soldiers" and the "Soldiers' Help Society" have agencies which spread into every district of the country. Moreover, the earlier age at which soldiers now leave the army has this effect, that most of them have parents or other near relatives still alive, many of whom are in regular employment, or are able to assist the men in obtaining situations. The "Soldiers' and Sailors' Families Association," with an agency in every garrison, is most useful to the married soldier during peace time. During the strain of the South African war it was invaluable.

Altogether, the "conditions of service" of the well-conducted soldier, though they still leave much to be desired, are beyond all comparison better than those of any army except that of the United States, in which the rates of pay are incomparably higher, although in other respects the physical comfort of the men is not so carefully provided for. In civil life a man has to pay for his own hair being cut and for repairs to his clothing, but he does this at his own good pleasure. The orderly appearance of the soldier is a necessity of discipline, and undoubtedly the fact that these minor payments are not matters entirely of his own option gives colour to an idea that when he has to pay for them he has not had the whole of the cash he expected. It is not a question of a broken promise to him, but the system will probably be modified in its working.

Supply of officers.

The test of an army is not peace, but war. Gauged by that standard it is not too much to say that, relatively to the facility with which the British empire is able to provide men for war on a large scale, the supply of officers has failed. The ordinary sources of the supply of officers to the army during peace time are, as they have been for many years, Sandhurst College for those of the Cavalry, Guards, and Infantry of the line; Woolwich for the Artillery and Engineers; and, as a further source of supply for all, the Militia. In addition, a certain number of commissions are given in all branches of the service to cadets of the Royal Military College at Kingston, Ontario, and to other colonies, while a few are given to men from the ranks. Commissions have during the war in South Africa been given freely through universities, public schools, and other institutions.

During peace time, as will be seen when we speak of "the organization of the higher units for war," the staffs necessary for these and for the "lines of communication" in the field have not been maintained. The loss of officers in war is enormous. The consequence has been that everywhere, whether in the field or at home, the supply of officers has been wholly inadequate, and the battalions and regiments have been left deplorably short. At home, when it was necessary to create new units, the men could be obtained, but officers, especially experienced captains and subalterns, were wanting. A nominal "reserve of officers" existed in the sense that officers who had retired on their pensions were liable to be recalled to service; but changes in army training have proceeded with immense rapidity of late years, and when officers, who had left the army for some years, returned to it they found the conditions to which they had been accustomed greatly modified. Captains and majors who returned in those ranks were the contemporaries in age of men who occupied the higher ranks in the army.

The disproportion between the officers with the British army in this and in former times may be best shown thus:—In 1815, at Waterloo, Seton's famous battalion, about 1000 strong, had forty-two subalterns on parade; in the battle its front was never more than about 500 paces. In 1901 a garrison of 5800 men at Woolwich had for some months seventeen captains and subalterns, all told, of whom ten were second lieutenants too young to serve on a court-martial. At Driefontein (10th March 1900) the Buffs, including regimental staff, had one officer per company. Companies often covered more than 1000 yards.

A very large number (2700) of second lieutenants were commissioned during the Boer war. Many of these from the universities, from the Colonies, from various technical colleges, were men of an excellent stamp, but they have for the most part (except those from Kingston) had no previous military training. Some of them were twenty-six years of age. So far as their future prospects are concerned this is a serious matter, because, in order to keep the various ranks of officers young enough to be fit for their work, the rule now is that a

Captain (unless he is a brevet-major) must retire at 45 years of age.
A major . . . . . " " 48 "
Lieutenant-colonel . . . " " 55 "
Colonel . . . . . . " " 57 "
Major-general . . . . " " 62 "
Lieutenant-general or General . " " 67 "

As a rule this is a scale which corrects itself to some extent, since, if promotion has for a time been very slow, many men in the senior ranks have to retire, and more rapid promotion is given to the juniors. The effect of a war on so large a scale as that in South Africa is to upset this condition. Large numbers of officers in the senior ranks are relatively young. The accession of the immense number of subalterns of the same age as those much senior to them will force these junior officers out of the service in large numbers. The circumstances for some years, therefore, will be very exceptional.

As regards the general question of the supply of officers, it must be realized that one of the exceptional advantages of Great Britain as a military power is that it possesses a larger class of the type from which effective officers can be drawn than any other country. What restricts the supply for war is solely that, as a question of economy, the policy of Great Britain has always been during peace time to reduce to a minimum the number of officers actually employed. Many posts are occupied by officers who are borne on the strength of their regiments and counted as if they were effective. The result of not maintaining during peace time the staff appointments required for war, and of filling a considerable proportion of those that are maintained with officers who are thus counted twice, is obviously to leave a very small proportion of the men who might be utilized available for war. Very large numbers of officers are "specially employed" in all parts of the empire. These cannot be recalled for a war in a particular part of it. They are borne on the lists of certain regiments as subalterns or captains, and after a time they are "seconded," that is to say that, their names being placed in italics, their places are filled up by the promotion of other officers. They retain their position in the regimental list, and may or may not at some time or other be brought back into the regiment. The demands of the staff in such a campaign as that in South Africa are so enormous that the same process has necessarily been applied to fill it. The effect is that there are many regiments of which the nominal establishment is, say, twelve captains, which actually bear on their lists twenty-four, of whom twelve are thus "seconded." The whole subject is undoubtedly one that requires immediate attention.

Since 1870 enormous reductions have been made in the numbers of the higher ranks of the army. Thus, excluding the Indian army, which had its own list in 1870, and the Indian Staff Corps, which as to officers was the corresponding body in 1901—

The Generals have been reduced from 71 to 10.
The Lieutenant-generals ,, 115 ,, 25.
Major-generals ,, 188 ,, 74.

At the same time the pay of all the higher appointments in the army has been greatly reduced. In the first place, the colonel-commandantships (worth per annum £1800 for a general from the Household cavalry, £2000 for a general from the Foot Guards, £1000 for infantry, £994 for the Artillery, and £990 for the Engineers) have all been abolished. These formerly were held in addition to the pay of the higher appointments. The actual pay of the higher appointments—commander-in-chief, adjutant-general, quartermaster-general, governors of Woolwich and Sandhurst, &c.—have all been reduced by many hundreds a year each. It will be seen, therefore, that from the increase of the army contemporary with these reductions in the higher ranks, the transference of expenditure from the higher to the lower ranks has been large, and that, actuarially, from the great increase in the number of junior officers, the prospects held out to an officer of reaching the higher ranks have been greatly reduced. A royal warrant, which came into operation on 1st January 1901, still further reduced the higher ranks. From that date no promotion from major-general to lieutenant-general was to take place except as a reward for distinguished service in the field or to fill an actual appointment. As the number of appointments held by lieutenant-generals had been much reduced, this further reduced the number of lieutenant-generals to fourteen.

It follows inevitably from the fact that officers, other than regimental officers, have not hitherto during peace time been employed in the positions which they will occupy in war, that they have not nearly all been trained in the specific duties of those positions. The staff is trained at the "Staff College" as far as that is possible without the discharge of the actual functions that have to be learnt. The number of officers that gain this functional training is very small. There is a great standing camp at Aldershot which normally in peace time has had the staff for one cavalry brigade, for three infantry brigades, and for one "brigade division" of horse with two of field artillery, besides the standing staff of the district. These numbers have been usually increased during the drill season, partly by bringing in from other stations regular troops, and partly by the addition of large bodies of militia and volunteers. All branches of the service go through a regular course of regimental training each year. This is specially designed to give each company-commander of an infantry battalion, each squadron-commander of a cavalry regiment, the opportunity of working up his unit before the whole are brought together for work under the lieutenant-colonel commanding the battalion or regiment. The several battalions, regiments, batteries, companies, and squadrons are inspected by their commanding officers and by the generals under whom they are serving. There is also a special technical inspection for the Cavalry and Army Service Corps by the inspector-general of Cavalry, and for the Artillery by the generals of Artillery at Aldershot, Woolwich, and Portsmouth. Musketry instruction has of late years been given under the general superintendence of musketry instructors and the supreme regulation of the head of the school at Hythe, but in detail by the captains of companies. This has been a great improvement in the training of the officers themselves. The competition between battalion and battalion and between company and company has been keen.

Training of officers.

Between each rank, from subaltern to captain, from captain to major, up to the rank of lieutenant-colonel, an officer is required to pass an examination before a board of officers, who have to certify that he is fit for promotion. The examinations involve answers on paper and also the handling of troops on ground. As a rule, all the paper questions are only such as an officer might actually have to deal with when in command of troops. Thus the system of "training," apart from special arms, has consisted rather in ascertaining that officers have trained themselves than in any very systematized method for giving them that training. The "Staff College," the "Ordnance College," each train special classes of officers. Officers on the staff are detailed for "garrison instruction," but in the main the training has depended on battalion commanders, the effect being afterwards tested.

The training of men is mainly involved in and connected with that of the training of officers; but it is necessary to add that, in the recruit stage of late years, the most important change has been the large development of gymnastic instruction on a methodical system, devised for the development of the several parts of the body. The tendency has been

Training of men.

more and more to substitute this for what used to be known as "setting up" drill, which was too formal for modern requirements, and did not combine the suppleness with the smartness needed for military purposes nearly so well as the modern gymnastic course. Moreover, since one of the great objects of modern training, both for officers and men, is to carry organization in working down into the smallest fractions of an army, the training of comparatively small gymnastic squads in orderly movement by their own company officers affords important facilities for this purpose.

Organization and special training of cavalry.

Shortly before the beginning of the Boer war, in the course of 1897, the cavalry underwent a new organization. Two cavalry regiments had been despatched to South Africa. There were then left in the United Kingdom eight regiments on a higher establishment and eight on a lower, which were each by this organization made up into three service squadrons and one reserve squadron. The higher establishment regiments had 670 men and 465 horses each, the lower 555 men and 343 horses. The 1st cavalry division was composed of five regiments on the higher establishment and a composite regiment of household cavalry. The 6th regiment of line cavalry was detailed as corps cavalry for the 1st army corps. Each squadron was 140 strong including officers. The object of this reorganization was to enable the regiments to start on a campaign without drawing on other regiments for non-commissioned officers and men. When the regiments went abroad the "reserve squadrons" left behind became in fact each regimental depots. There are always about 200 "non-grooming" men in a cavalry regiment required for various purposes, so that this proportion of horses to men was deliberately arranged. During the war a great strain was thrown on the "reserve squadrons." As recruits and remounts were poured into them they virtually came to be, in point of men and horses to be trained, equal in numbers to a cavalry regiment. The supply of officers and non-commissioned officers and the "office" were wholly inadequate for dealing with such numbers. There can be little doubt that considerable modification will necessarily be made in this provision for any future emergency.

The Boer war, in which the power of the new weapons made itself so conspicuous, has naturally led to much discussion as to the future rôle of cavalry. There is a disposition to assume that cavalry should abandon its old position of looking upon manœuvring facility and the *arme blanche* as its ruling *metier*, and should become, like the American cavalry of the civil war, a manœuvring mounted infantry. It is, however, premature to draw conclusions from the incidents of a very exceptional struggle, and until the question can be more fully discussed it should not be prejudged. On one point all the experience of the past may doubtless be trusted. It is necessary to decide definitely whether cavalry is to rely on a knowledge of ground, on horsemanship, skill in manœuvring, and the *arme blanche*, or whether it is to trust to dismounted fire. To train men both to charge home and to believe in victory in so doing, and at the same time to think that their only safety lies in dismounted fire, is a contradiction in terms. It would be wholly contrary to human nature if such training proved successful. That cavalry, if in the proper use of their arm they are to act effectively, must be supported and aided by mounted infantry, is not a new experience, though it has been much emphasized by the South African war. The immense numbers of mounted men ultimately employed were a necessary consequence of the peculiar nature of the contest, and not necessarily a certain element of future war under normal conditions.

Artillery.

The changes of late years both in the organization and training of artillery have been very numerous. In the first place the old "royal regiment" has been divided into two distinct branches, so that the promotion of officers is no longer carried ont in one long list. The officers for the field and horse artillery stand now on one seniority list for promotion, the garrison and mountain batteries on another. Within each branch important changes of organization have been also made. In the field branch of the regiment, both for "field" and "horse" artillery, the battery is no longer the one "unit" for all purposes. A lieutenant-colonel's command, which for the present bears the anomalous name of a "brigade division," has been created. It consists of a group in the horse artillery of two, in the field artillery of three batteries. As yet, the organization is not carried to its logical conclusion. The lieutenant-colonels belong to particular stations, the batteries move from station to station. Thus the elements composing the "brigade divisions" are continually changing. Moreover, the "staff" of the brigade division is only formed by taking officers from the batteries temporarily attached to the command. It is much to be hoped that this may soon be modified, and a beginning has been made by the appointment of warrant officers as sergeants-major of the brigade division. For the training of the horse and field artillery a large area of ground on the wild open country of Dartmoor, near Okehampton, has for some years been utilized. A similar school has been started at Glen Imaal in Ireland. There it is possible, to a large extent, to combine the actual firing with service ammunition, the bursting of shells and the practice at dummies representing artillery, cavalry, and infantry, with training in rapid changes of formation and field movements. For these purposes the brigade divisions move together and are trained together. An elaborate system of "fire discipline" has been worked out in order to bring the whole fire of a battery completely under the control of the officer commanding the battery, so that the officer commanding the brigade division may be able to use his unit for such purposes as may be required by the general's combinations. During the winter and early months of the year the batteries are trained in elementary work at their own stations. During the summer the brigade divisions give practical effect to the training either by preference at Okehampton, or if there be not time for all to go there, then some have hitherto been sent to Shoeburyness. A new training ground has been opened on the area recently purchased at Salisbury. There also actual firing with service ammunition is combined with field movements. This promises to become the most valuable field artillery school the army possesses. Similarly, with the garrison artillery, a much more perfect system has been devised for the regulation and practice of the fire of a fortress. The whole *personnel* of the artillery within coast fortresses is now organized so that the fire can be brought to bear upon the positions likely to be taken up by a hostile fleet. The invention and adoption of instruments known as "position finders" and "depression range finders" enables the fire to be directed with great precision upon given spots likely to be passed by ships. To a large extent the actual organization of the defence depends on the special nature of the fortress. The organization of the defence of a fortress like Gibraltar or Malta must obviously differ from that of a tortuous channel such as gives approach to the harbour of Harwich. In general terms the manning of the sea-board guns of the British islands depends upon militia and volunteer artillery, with only a small stiffening of regular garrison artillery. The proportion of officers of the royal garrison artillery militia and volunteer artillery are periodically trained in the different works to which they are assigned. A practice school for the garrison artillery has been established at Lydd, but the various coast fortresses themselves carry out regular practice with service ammunition.

Infantry.

It is one of the peculiar characteristics of the service of the British army that, from the extent and dispersion of the empire over the world, it is almost always at war on a greater or less scale. If the temple of Janus were, as an indication of peace, closed for one year, it would have the next to be opened at four doors for four different wars. Thus in 1900, independently of Indian frontier expeditions, of which there were more than one in the year, Great Britain had war in the Egyptian Sudan, war on the West Coast of Africa, two expeditions in East Africa, and war in China, whilst the war in South Africa was going on. The practical training of the British infantry more than that of any other army is necessarily affected by this fact. Not only are the experiences through which officers and men pass in these wars very important in their effect on the preparation which they give for future war, but they have a great influence on the permanent training of the army, and especially of the infantry, during peace time. Now even in this one year, 1900, no two of the wars were alike in their circumstances; and, unless the comparison be made between some two Indian frontier expeditions, hardly in the thirty wars of the thirty years 1870-1901 would it be possible to find two of which the tactical conditions were identical. In these circumstances the actual views which dominate British schools of training are apt to be modified considerably by the most recent experience. This modification finds expression to some extent in the successive drill books which are issued. It is in reality much more important in its influence through the decisions given by umpires and the comments on field days. The influence of the experience of the great war between France and Germany in 1870 showed itself in the training of the British army for some years in a much more open order of fighting, in the continual study of ground with a view to cover, and in carefully-arranged turning movements. The influence of wars in which Zulus and Mahdists showed the power of determined attacks pushed home regardless of loss, had its effect on our training in a tendency to encourage frontal attacks provided that a certain numerical superiority was attained at a given point. The actual training imparted at any given period in the camps at Aldershot or Salisbury has oscillated much between these extremes. The training of the other arms being largely dependent on the principles adopted for infantry in defence and attack, it is safe to say that there is this necessary contrast between the adequate training of the British army and that of any other European Power, that with the British army the officers at least, and to some extent the men, require to be prepared for many varied circumstances and conditions, whereas in the training of other European armies the conditions under which they will enter upon war are fixed and well known beforehand. The extent to which a British army is prepared by training for a given war must depend on the extent to which all the conditions of that war have been studied beforehand. In one respect, however, so far as the infantry is concerned, all wars are alike. In every war the most important power of infantry depends on the efficiency of its training in the use of the rifle. In this respect several changes of importance have been made of late years in the British army. First, the actual detail training of the men has been put into the hands of the company officers, and they have been made responsible for it. Secondly, at Bisley and other places a system of "field-firing" has been introduced. This consists in a most valuable combination between manœuvring to take up the right position from which to bring fire to bear, and the actual shooting at dummies placed to represent different bodies of troops arranged so that they can be made to appear unexpectedly in a position previously unknown. Further, the combination between drill manœuvres and shooting has been improved by requiring the actual orders for all firing to be given during the course of drill manœuvres in such a way as to determine the object to be fired at, the range, and the nature of the fire. Nevertheless, recent experience makes it almost certain that, under the present conditions of war, almost all firing will become individual and independent. The purchase of a large area of ground near Salisbury has given scope for manœuvres on a much larger scale than was possible formerly. As, independently of this, an Act has been passed to give facilities for the carrying out of manœuvres on varied ground to be chosen from time to time, it is to be hoped that when events at home resume their normal course, annual manœuvres may be carried out in different parts of the country. The system of training at present consists during the winter in regularly graduated route-marches, accustoming the troops to carry their equipment and arms for long distances. At the same time indoor and barrack-yard instruction is given in elementary duties, in the principles of scouting and protection on the march, and in such other matters as may tend to interest the men in their work, such as the nature of their weapons, accounts of what the battalion has done in the field, and of other incidents of war. In the spring each company in succession is relieved of all other duties in order that it may go through a course of systematic instruction under its company officers. After the different companies have been inspected by the lieutenant-colonel and employed against one another in minor field days, the battalion is worked together as a whole. At Aldershot, the Curragh, and at special camps, the brigades of infantry are then worked together, after which the training ceases to be arm training and becomes that of the combined arms. In principle, and according to the instructions issued from headquarters, all training is conducted on the principle of giving great latitude to the company commanders, accustoming them to decide for themselves, and to train the subordinates under them to exercise similar responsibility. In practice it is to be feared that old habit and military conservatism have tended to keep all responsibility and power too closely in the hands of the lieutenant-colonel. Probably one of the most important effects of the South African war will be to bring before the eyes of the army the indispensable necessity of training all officers to exercise an increased responsibility. In any case training for war depends much more upon the spirit which in these respects animates an army than upon any formal regulations.

Engineers.

The special training of the Engineers is mainly given at Chatham, and embraces a very great variety of subjects, practically all the technical work of the army as described in the article ENGINEERS. As an "arm of the service" it is a common delusion to speak of the engineers as essentially "defensive." The experience of the South African war has perhaps tended to modify this popular error. Strategically the offensive action of the army there, as always in modern wars, has depended on the rapid construction of railways, the restoration of destroyed bridges, and generally on those means of rapidly improved facilities for advance for which an army depends on the engineers. For that reason, even in Napoleon's time, engineers have always been present with the advanced parties of every column when moving forward with an army. Without the pontoon train, bridging detachments, and the parties for removing obstacles, an army would be incessantly delayed, independently of the necessity for much larger operations on great rivers and on the general lines of railway. The changes that have taken place and are continually taking place in the detail of engineer organization and equipment simply consist in the adaptation to military purposes of the progressive advance of science. Otherwise there is little to note in any changes of organization in the corps. The development of hasty entrenchment in connexion with the movement of armies in action has become and promises to become still more one of the most marked features of the present phase of war. It is at least as important on the offensive as on the defensive side.

Mounted Infantry.

The Boer war has concentrated attention on the extreme importance of the rapid transfer of shooting power from point to point of a field of battle or of a campaign. The exceptional circumstances of the campaign have perhaps tended to leave an undue impression, both of the degree in which this is a novelty and of the extent to which it promises to dominate future warfare. Napoleon gained most of his exceptionally brilliant battles during the 1814 campaign, when with a handful of men he was keeping back the overwhelming masses of Allied Europe by this very means. He moved from side to side of the theatre of war the whole of his brigade of guards on country carts. It must be understood that the horses or cobs that are employed with the detachments of infantry, who have been trained at Aldershot and elsewhere, are only intended to supply the place of Napoleon's country carts. It may for various reasons be doubted whether under most conditions of warfare the cart is not the vehicle to be preferred. It is a question of circumstance. The Boers were a nation of trained riders and trained shots. In its Colonial troops and in some of the home yeomanry the British Empire possesses similar material. It is obviously desirable to utilize this material. The question is altogether apart from that change of the equipment, rôle, and training of the cavalry arm, which has been discussed under cavalry. At present there is no organized body of mounted infantry as such as a peace branch of the British army. For the purposes of the Boer war regularly formed brigades of mounted infantry have been created out of the various contingents of mounted infantry furnished by home battalions and the Colonial corps.

Cyclists.

There can be no doubt that, especially in a country like England of numerous and excellent roads giving immediate access to favourable ground in which to delay and puzzle an invading enemy, the bicycle has established itself as a most valuable agent in war. It is certain that the tendency of time will be greatly to enhance its importance not merely for the purposes for which it has been frequently used, those of saving horses by its use for orderlies and for scouting, but for delivering more considerable bodies within the fighting area. There are such large numbers of men available who can both shoot and ride, or who can do one and would easily learn to do the other, that it is impossible that this valuable material should be long left to go to waste. Only practice and organization are needed to develop a most useful auxiliary in the defence of the country, and the volunteer companies that have been started promise to be the forerunners of a new arm for the British army.

Army Service Corps.

The transport and supply departments have been formed into the Army Service Corps, organized by companies with senior officers locally appointed, very much as is done in the case of the royal artillery. The Army Service Corps is administered through these senior officers directly from the War Office, under the orders of the several general-officers commanding districts. The officers appointed to the Army Service Corps after a probation from regiments of the line, during peace time undertake the purchase of forage, and have under their immediate supervision such transport as is kept up during peace time. They have the privilege of being appointed to the staff for what are known as B duties, that is, virtually for the work of the quartermaster-general's department—food-supply and transport for man and beast. Contracts for these are made by them under the authority of general-officers. They superintend the bakery establishments and the abattoirs.

Hitherto in the matter of transport one large branch has been distributed to battalions under the title of "regimental transport." It was taken charge of and cared for by the battalions. It would seem probable, from the reports on the subject made by Lord Roberts, that this arrangement will be modified. Originally it was designed to enable regiments to have transport always available for their immediate needs on the march, and to bring up their supplies from the local depot. This was objected to in Africa, because it deprived the army at large of the services of that part of the transport which belonged to battalions not at the time on the move.

Ordnance.

The Army Ordnance department was reconstituted on 31st March 1900. The Army Ordnance Corps is immediately under the director-general of ordnance, and consists, as to officers, of a principal ordnance officer ranking as major-general, of eight 1st-class ordnance officers ranking as colonels, of fifteen 2nd-class ordnance officers ranking as lieutenant-colonels, of twenty-five 3rd-class ranking as majors, of fifty-three 4th-class, of commissaries of ordnance, deputy commissaries of ordnance, assistant-commissaries of ordnance. It is charged with providing, receiving, holding, and issuing munitions of war, military stores, clothing for use in camps, and both clothing and necessaries for use in the field. The corps consists of eleven companies with a depot company. It is, so far as the personnel of these companies with their non-commissioned officers and men is concerned, administered from Woolwich by the ordnance officer, 2nd class, who is in command of the depot there. He acts for this purpose as staff-officer to the director-general of ordnance. It is, however, difficult to say whether the functions of this department are more important at home or in the field. Some estimate of the nature of its functions may be formed by the following list of articles sent out to South Africa *before the fall of Pretoria*. We have not the figures of a later date, but obviously the special strain was prior to that event. Afterwards it became simply a question of keeping up such further supplies as were asked for. We record the figures chiefly because we believe them for a despatch to a campaign 7000 miles off to be unique in the world's history.

Ammunition.

Over	105,000	rounds	for	the	12-pr. horse artillery gun
,,	330,000	,,	,,	,,	15-pr. field gun
,,	30,000	,,	,,	,,	5-in. howitzer
,,	20,000	,,	,,	,,	5-in. gun
Nearly	21,000	,,	,,	,,	4·7 gun
,,	380,000	,,	,,	,,	pom-pom (37 millimetres)

Clothing.

Drab suits	much over	200,000
Khaki suits	about	80,000
Boots (pairs)	over	370,000
Woollen drawers	,,	400,000
Jerseys	,,	200,000
Worsted socks	,,	850,000
Cotton socks	,,	170,000
Flannel belts	,,	400,000
Flannel shirts	,,	500,000

General Stores.

Circular tents	18,000 or thereabouts
Blankets	over 420,000
Waterpoof sheets . . .	,, 300,000
Camp kettles	,, 37,000
Horse rugs	about 100,000
Sets of ten or six spare mule harness, nearly	6,000

Medical Department.

The medical department is administered from the War Office by a director-general and his staff. It is now formed into the Royal Army Medical Corps, to which officers are gazetted with commissions. The Army Medical Staff consists of ten surgeons-general. The Royal Army Medical Corps consists of colonels, lieutenant-colonels, majors, captains, and lieutenants. There are about 900 officers in all, besides 50 quartermasters. There are 36 warrant officers, 336 staff-sergeants and sergeants, and before the war rather more than 2000 rank and file. These were supplemented during the war by civil surgeons specially engaged for the war, both in South Africa and at home, and by the employment of volunteer medical orderlies. The chief general hospitals are at Netley, Woolwich, and Aldershot. There are also station hospitals, lunatic hospitals, and hospitals for women and children.

For service in the field, bearer companies, field hospitals, station hospitals, base hospitals, and general hospitals at various points on the lines of communication have been set up. Convalescent homes, both for officers and men, were found necessary in the South African campaign, and would probably be always used in any protracted operations. In the army corps organization one bearer company and one field hospital is attached to each brigade of cavalry or infantry, one field hospital to each of the divisions as such, and one field hospital to the corps troops. With the army corps there are six bearer companies, ten field hospitals. During a campaign a medical officer is attached to each unit and has especial charge of the regimental stretcher-bearers.

Each "general hospital" has a staff of women nurses, consisting of one superintendent, eight nursing sisters, two female servants.

Auxiliary Forces.

An attempt has been made of late years to connect the militia and volunteers more closely with the regular forces by constituting every corps, whether of militia or volunteers, as a "battalion" in name at least of a particular regiment of which other regular battalions formed part. As the several battalions of regulars and militia or volunteers are never or only accidentally associated, the arrangement is little more than a paper one. Independently of this the volunteers have been nominally formed into brigades under "brigadiers." These officers have little or nothing to connect them with their brigades except on those few occasions when the brigade is, as a whole, brought out to a camp of exercise. Normally during peace time all the work of inspecting and carrying on the correspondence of volunteer battalions and batteries is done by the colonel of the "regimental district," who has under him the depot of the regular battalions and all the militia and volunteers of the territorial region to which the regiment is assigned. He in fact constitutes the link between the several auxiliary forces and the regular battalions. The adjutants of the volunteers, and the adjutants and quartermasters of the militia, and the non-commissioned officers forming the "permanent staff" of the militia, and the instructors of the volunteers, are detailed from the regular battalions of the regiment, but at that point the connexion has hitherto stopped. The numbers of militia on the 1st January 1901 were 92,741, and of volunteers, 277,900. During the year 1900, in consequence of the Boer war, the whole of the militia were embodied, that is to say, called up for home service and regularly brought on pay. Thirty-five battalions, having volunteered for service abroad, were sent to South Africa, St Helena, or the Mediterranean. This has been the customary practice of war in relation to the militia, and constitutes them an exceedingly valuable force for setting free the active army in the field. Unfortunately, during peace time their opportunities for rifle practice had been so limited that comparatively few if any of these men had been through any musketry training before they sailed for their foreign station.

In the case of the volunteers the patriotic zeal of the year 1899-1900 led to a new departure, and created a new link between them and the regular battalions of the "regiments" to which they both belonged. Seven thousand volunteers joined by companies the regular battalions, and were enlisted as regular soldiers for the year, while 2163 volunteers enlisted in the army reserve.

Total British army.

Seeing that the "British army" is the army as it is in war, it appears advisable to show in the following Table A, taken from the report of the inspector-general of recruiting, the different sources from which the number of regularly enlisted forces for home and colonial service had been increased from 290,914, at which it stood on 1st January 1900 after the general mobilization, to 406,443 by the 1st January 1901. This shows only non-commissioned officers and men, and allows for loss by death (10,153) and other causes, in all, including deaths, 37,269. It is put after the auxiliary forces because it will be seen how largely they contributed to swell the total. The regular forces on the Indian establishment of all arms and ranks are given in the army estimates at 63,023. These, the total establishment of officers, the militia (100,008), various colonial militia, the remainder of the army reserve after mobilization, the native Indian regiments (22,313), the yeomanry (8657), the volunteers (277,900), and the numbers on the general staff have to be added to those in Table A. Together they make up a total, exclusive of the local forces of the self-governing colonies, of about 840,000.

TABLE A.—*Home and Colonial Establishment (Rank and File).*

	Effective on	
	1st January 1900.	1st January 1901.
Household cavalry . .	1,244	1,518
Cavalry of the line . .	21,389	30,075
Imperial Yeomanry . .	...	8,824
Royal Artillery—		
Horse and Field . .	25,888	34,046
Garrison . . .	21,982	24,886
Royal Engineers . .	9,436	12,780
Foot Guards . . .	11,740	13,846
Infantry of the line . .	178,745	216,221
Infantry, reserve regiments	...	17,961
Colonial troops . . .	8,512	30,221
City of London Imperial Volunteers[1] . . .	...	...
Army Service Corps . .	5,069	7,536
Army Ordnance Corps .	1,593	1,984
Royal Army Medical Corps	4,068	5,551
Army Pay Corps . .	558	621
Army Post Office Corps .	160	374
All arms . . .	290,384	406,443

Mobilization.

The term "mobilization" is one which is in fact due to the short-service system. It implies the calling up of the "reserve" created by relegating to civil life the trained soldiers who are held to serve when called upon. It implies the complete equipment and clothing of all that part of the army which is "mobilized" with equipment and clothing not necessary for peace service, but kept ready for war. It implies a vast increase in the number of horses required by the army brought in from civil proprietors who have their names registered for the purpose. It implies the creation of a new "reserve" to keep up the numbers of the units in the field. This new reserve is formed in the following way:—When the "reserve" soldiers are called up to the colours those young soldiers who are not sufficiently trained to take their places in the ranks, or are not yet of a suitable age to be sent out, are relegated to depots left at home, their place being taken by the men from the reserve. There are also a large number of the "reserve" who are not required to fill up the vacancies in the battalion going out. These become what are known as "excess numbers." Naturally, the men left behind are at various stages of training. Some of them will in a month or so have completed their musketry training, and will then be quite fit to take their places in the ranks. Others have been laid up by some temporary accident or passing malady. It results from this that every month there are always coming on fresh men ready to take their places in the army at the front. The "excess numbers" of the reserve help largely to supply any deficiency. In this way, as a matter of fact, the numbers in units at the seat of war, as they have suffered from the attrition that wears them down in the field, have been kept during the South African campaign more regularly supplied with drafts than has been the case in any other in which the British army has ever been engaged, and much more perfectly than is recorded as the ordinary condition of most armies during a campaign. It is therefore a point not worth discussing whether the term "reserve" is or is not properly applied to the particular men who are called the reserve (because, as it is said, a "reserve" ought not to consist of men who are, many of them, at once put into the ranks in the field). That mistake, if it be a mistake, has been made by every nation in Europe; but in any case, the reserve behind the front, the reserve which fills up the losses of a campaign, has been provided more perfectly by this system than by any other that Great Britain has ever had. Moreover, for the purposes of keeping up a uniform strength at the front, it is one that continually and automatically renews itself, because, by the time that the "excess numbers" and the earlier lists of young soldiers who have been gradually sent out to the war in drafts have been exhausted, *this* reserve is supplied from fresh sources. Men wounded in the early stages of the campaign, or indisposed without being very seriously ill, begin to arrive at the depots after convalescence. The recruits enlisted since the war are, many of them, beginning to come to maturity. The interest and excitement of the war has drawn back into the ranks older trained soldiers who have offered themselves. In short, from various causes the drafts can be filled up month by month. This, of which we have given such an ideal sketch as presented itself to the minds of the framers of the scheme, is precisely what happened during the South African war. That was the value and importance of those 90,000 odd soldiers of whom we have heard as existing in England after the main army had been sent to South Africa, who, though they were not an army fit to take the field because they were only "details," were yet an invaluable element in keeping up the fighting strength of the army.

---

[1] Effective (1900) less than one year, 1664.

It is necessary further to observe that, whereas for Germany or France the time which mobilization ought to take depends on a competition in readiness with a neighbour across a frontier, for Great Britain that time depends on quite a different consideration. If the men are completely ready to embark as soon as the ships can be made ready for them, that represents the time and the only time at which there is any object in aiming for any other purpose than that of home defence.

Organization of higher units for war.

The organization of an army for war is designed to make it a body as flexible and mobile as possible in the hands of its commander. The ideal army that Wellington had formed by the end of the Peninsular war was one that could, as he expressed it, "go anywhere and do anything." The organization of the British army during peace time has hitherto been essentially an organization by stations—a stationary organization. The units composing the several garrisons of the stations are in a continual state of flux and reflux. There has hitherto been no higher organization anywhere maintained as a whole complete in all its parts for more than a short time. In part this is an inevitable consequence of the different conditions of service between the army of a world-wide empire and that of countries like France and Germany, which have all their peace duties within a ring-fence of the borders of their fatherland. The corps which in Germany occupies a particular district is designed to move as a whole when it is required for war. The troops, which in England are stationed in a certain locality, have two entirely distinct functions. The several units are on a roster for foreign service, and will each in their due turn go to India or the Colonies, being replaced by other units from abroad. In the event of war they have hitherto been formed with other units into brigades, divisions, and army corps, but they have not been in these organizations prior to the preparation of the expeditionary army. The generals to command and the staffs to direct them have been appointed for the special purpose. To this there are two slight exceptions to be made. At Aldershot, in addition to the stationary headquarters staff of the general in command, there have been stationary brigadier-generals with their staffs. The units composing the brigades have been in the same condition of flux and reflux as the other parts of the British army. Aldershot was, up to the time of the acquisition of the ground at Salisbury, the one great training-place of the British army in England, just as the Curragh is in Ireland. It is still the principal training school of the army. Therefore, in order that all parts of the army may share in this training, battalions and batteries have been only kept there for a short tour and then either gone out to stations abroad or taken their turn at other stations at home.

Thus the permanent peace organization of the higher parts of the British army has remained as described in the ninth edition of this Encyclopædia, one of district commands. The organization for war has been a paper organization, different in practice for each campaign, according to its nature, but having as a basis the tabular statement of units given in Table B, which is at present the paper organization of an army corps.

The other exception to the rule of perpetual flux and reflux has been the brigade of Guards. The three regiments of the Grenadier, the Coldstream, and the Fusilier Guards, to which was added in 1900 the regiment of Irish Guards, are not liable to ordinary or colonial service. Therefore, their organization at home remains constant, and they are available as a whole for active service in the same organization in which they are trained in peace. The close connexion by short steam journey with Gibraltar caused that fortress to be treated for a short time as a home station, and garrisoned by the Guards in order to reduce the number of line battalions abroad in proportion to those at home. That arrangement was soon given up, and it may therefore be treated as a temporary episode, but it did not very materially affect the broad distinction between the permanency of the Guards' organization and the perpetual change of all other units. The new scheme laid before the House of Commons by Mr Brodrick in 1901 was an attempt to meet the difficulty which has hitherto prevented the training at home of bodies such as are at once required for action in the field. It is pointed out in the ninth edition of this work that "as the battle-field is the ultimate object of all preparation, administrative considerations must give way to tactical ones where they clash, and all organization must conform to the tactical requirements of the day." Unfortunately, the administrative difficulties which attend a vast empire, a free constitution, and voluntary service, and the indispensable condition of presenting an economical budget, have hitherto prevented the practical application of this sound principle. In order to create the reserve for filling up the ranks for war, and to provide for the colonial reliefs, it was arranged that there should be a battalion at home which should supply the battalion of the same regiment abroad with the annual draft required. This consideration became so paramount, that the importance for the purpose of training staffs for their work in war, and, therefore, of having constituted staffs to train, fell into the background at a time when the nation only calculated upon having to prepare for minor operations. There can be no doubt that the South African campaign plainly showed that trained staffs, accustomed to work together, and each to know its own particular share of the work, are indispensable to the smooth working of a large organization. The plea that it is frequently necessary to send out forces no larger than a division, and, therefore, that an army corps is not wanted, is not a strong one, because a division, or a force of similar strength, will not be the less effective because it is taken out of a larger body habitually associated with it, and out of which it can be supplemented by other troops with which it has regularly worked.

We give in Table B the ordinary composition of a British army corps, because it is well that the term should be understood; but, ever since this form of organization for armies was created, army corps have been of an infinite variety of form. All that the term implies is that it is a little army complete in itself, formed of every branch of the service, and being made up with all that is necessary to enable it to take its place in the field: that in itself it stands ready for war as soon as it has been mobilized. An army made up of army corps consists of several associated small armies, each capable of independent action in all respects. The "divisions," though called "infantry divisions," in fact consist of all arms, and frequently the several arms have been distributed throughout the divisions to form what are called "mixed divisions." In the German army there is a double organization by which, while the several arms are associated together, unit by unit, larger bodies of each arm are for the purpose of working in larger bodies of the arm associated together.

Supply of troops for India and the Colonies.

The great difficulty which encounters any attempt to associate large bodies of troops in England without flux or reflux, lies in the necessity of making provision for the constant interchange and relief between the units at home and abroad. The "cry of the exiles" is too strong to permit of their being left abroad for more than a reasonable number of years, and experience has shown that there are grave disadvantages in allowing two separate systems to grow up in different parts of the empire. On the whole, it has proved better for the training of drafts that they should not be sent direct from depots to India, but that, after a few months with the depot, they should be passed to battalions which will, in turn, later in the year, send on a draft to the sister battalion in India. In order that this may not injure the home battalion it is necessary that the draft should bear only a limited proportion to the strength of the nucleus of the battalion, and that the draft supplied early in the year to the home battalion from the depot should considerably exceed the draft to be sent out later to India; but, if provision be made to that effect, the system appears to work best for both battalions. A similar allowance is necessary for the cavalry, and even more for the artillery, because in the case of batteries it becomes a question, if the draft is too severe, of the loss of specially trained men. Independently of the movement of drafts, the change in units will involve special provision if the value of the permanent organization by army corps is not to be lost.

TABLE B.—*The Army Corps.*

	Officers.	Warrant and N.-C. Officers and Men.	Total.
Staff	34	137	171
3 Infantry Divisions	978	29,124	30,102
1 Cavalry Regiment	25	506	531
Headquarters Cavalry Regiment	7	44	51
Corps Artillery (6 field, 2 horse batteries)	60	1,639	1,699
Ammunition Park	20	672	692
Regimental Staff Corps Engineers	2	6	8
1 Pontoon Troop	5	208	213
1 Telegraph Division	6	238	244
1 Balloon section	3	51	54
1 Field company	7	205	212
1 Field Park	1	44	45
1 Railway company	5	153	158
1 Battalion Infantry	29	981	1,010
Supply Column	6	145	151
Supply Park	9	531	540
Field Bakery	5	312	317
Field Hospital	5	56	61
Grand total with Field Force	1207	35,052	36,259
Detail left at base	37	3,299	3,336

Transport—	
Horses, riding	2837
,, draught	7234
Pack animals	76
Total	10,147

Vehicles—	
Carts, 1 horse	55
,, 2 horses	309
Waggons, 4 horses	514
6 ,,	523
Total	1401

The War Office and general administration of army.

The War Office, as at present constituted under the supreme and absolute authority of the Secretary of State for war, is regulated, so far as its military personnel is concerned, by an Order in Council of the 7th March 1899. That Order, altering in certain respects the Order in Council of 21st November 1895, which is cancelled by it, provides for the distribution of the military branch into five great departments—those of the commander-in-chief, of the adjutant-general, of the quartermaster-general, of the inspector-general of fortifications, and of the director-general of ordnance. Each of these officers "advises the Secretary of State" directly on all questions connected with the duties of his department.

The several officers are assigned duties which may be summarized thus:—

Commander-in-Chief.—"Principal adviser" and "general superintender" of military departments. He is charged with the issue of army orders, inspections, the distribution of and "mobilization" of the land forces, with schemes of offensive and defensive warfare and military information, with *recommending* for commissions and *proposing* officers for promotion, honours, appointments, and rewards.

Adjutant-General.—Discipline, military education and training, patterns of clothing and necessaries, returns and statistics of personnel, enlistment and discharge, and establishments. In the absence of commander-in-chief, acts for him.

Quartermaster-General.—Food, forage, fuel, light, quarters, land and water transport, remounts, movement, distribution of stores and equipment, the administration of the Army Service Corps and Pay Department, sanitation.

Inspector-General of Fortifications.—Fortifications, barracks, and store-buildings, inspection of ordnance factory buildings, military railways and telegraphs, War Office lands and unoccupied buildings, submarine mining stores. Estimates for Engineer services, appointment and removal of officers Royal Engineers, technical instruction of Royal Engineers.

Director-General of Ordnance.—Warlike stores, equipment, clothing, the direction of the ordnance committee and manufacturing departments. Armament patterns, inventions and designs, inspection of all stores. The administration of the Army Ordnance Department and Army Ordnance Corps; annual estimates for these services.

The most important part of the War Office is, however, not mentioned in the Order in Council. The "sinews of war" have at all times been money, without which neither could the army exist nor any military operation in peace or war be undertaken. It is true that, as a kind of appendix to the Order in Council, the statement is made that "the *financial secretary* is charged with the whole finance of the army in gross and detail"; but it is not mentioned that the "War Office" is a great permanent civil service, which has both independent offices, with its own heads, and also permeates the whole of the five departments. The Secretary of State has under him, in addition to the officers charged with the five departments and the financial secretary, a parliamentary under-secretary, who represents him in the House to which he himself does not belong, and a permanent under-secretary, who is the head of the permanent civil service of the War Office.

The enormous relative power of the civil service within the War Office, as compared with the military heads of departments, depends on the fact that these latter are appointed for five years at a time, and pass and repass through the War Office, while the War Office civil service is a permanent body which preserves all the traditions of decades, and can cite at will the records of opinion given at different epochs by soldiers who have temporarily occupied chairs in the office. Soldiers, like doctors, lawyers, and parsons, when called in to diagnose a case, do not always exhibit an absolute and instant agreement in the statement of their views. A Secretary of State holding all authority is necessarily much more likely to be impressed with the consistency and weight, and the method of a carefully collected catena of opinions, than with the comparatively casual dicta of men, very much overworked as compared with the officers of any other department of the kind in Europe, and relatively unfamiliar with the office aspect of a question. The practical result is, that the ordinary conviction of nearly every soldier employed within the office has been that he was helplessly in the hands of the permanent officials. This is altogether apart from the question of the supreme authority of the Secretary of State as the representative of the Cabinet.

The committee which in 1901 reported on the reorganization of the War Office appears to have taken this view of the question, and to have considered that a better state of things would be produced if the authority of the War Office were largely devolved upon the army corps commanders to be created under Mr Brodrick's scheme. The practical possibility of this would appear ultimately to depend upon the extent to which Parliament will be content to accept reference to the army corps commanders as a final one as long as they are sustained in office. It is obvious that if the Secretary of State is to answer in Parliament for every incident that takes place in every army corps no practical independence can be left to any of them. Everything must be reported to the War Office in order to satisfy the demands of the House. It is a large question which can only be judged in its practical outcome.

In accordance with the recommendations of the committee on War Office Reorganization presided over by Mr Clinton Dawkins in 1901, the Secretary of State directed that in future the "War Office Council" should be constituted as follows:—President—the Secretary of State for War. Members—the Commander-in-Chief; the Parliamentary Under-Secretary of State; the Permanent Under-Secretary of State; the Financial Secretary; the Quartermaster-General; the Inspector-General of Fortifications; the Director-General of Ordnance; the Adjutant-General; the Director-General of Mobilization and Military Intelligence; the Director-General, Army Medical Department (for medical and sanitary questions); the Secretary of the Council; and such other members of the staff of the War Office as may be specially summoned from time to time. In the absence of the Secretary of State, the Commander-in-Chief acts as president.

A Permanent Executive Committee of the War Office was also appointed, with the object of co-ordinating the business of the office and of ensuring that combined action might be taken in matters affecting more than one department. It consists of the following:—the Permanent Under-Secretary of State, or, in his absence, the Assistant Under-Secretary of State, chairman; the Deputy Adjutant-General, or, in his absence, an officer selected by the Adjutant-General; the Assistant Quartermaster-General, or officer selected by the Quartermaster-General; a Deputy Inspector-General of Fortifications, or an officer selected by the Inspector-General of Fortifications; the Deputy Director-General of Ordnance, or an officer selected by the Director-General of Ordnance; an officer of the Mobilization section of the department of the Director-General of Military Intelligence; an officer of the Intelligence section of the department of the Director-General of Military Intelligence; the Deputy Accountant-General, or an Assistant Accountant-General; the Deputy Director-General, Army Medical Department, or an officer selected by the Director-General; the Assistant Director of Contracts; the Secretary of the War Office Council, who will act as secretary of the executive committee.

In addition to the above, the "Army Board," which consists of the Commander-in-Chief, the Adjutant-General, the Quartermaster-General, the Inspector-General of Fortifications, the Director-General of Artillery, with usually the military secretary, as assessor, and the Director-General of the Army Medical Department now added, meets at such times as may be fixed by the Commander-in-Chief.

TABLE C.—*Terms of Service.*

Corps.	With the Colours.	In the Reserve.
Boys	12	—
Household Cavalry	12	—
Cavalry of the Line	7	5
Royal Artillery	7	5

TABLE C.—*Terms of Service—continued.*

Corps.	With the Colours.	In the Reserve.
Royal Engineers—		
Sappers for Companies and for 1st and 2nd Divisions Telegraph Battalion	7	5
Sappers for Bridging Battalion	3	9
Drivers	3	9
Military Mechanists	12	—
Railway Reserve Telegraph Reserve Submarine Mining Reserve	3	3
Foot Guards—		
Bandsmen	12	—
Other Recruits	7	5
	or 3	9
Infantry of the Line	7	5
	or 3	9
Royal Army Medical Corps	7	5
	or 3	9
Army Service Corps	3	9
Army Ordnance Corps—		
Armourer, Machinery Artificer Sections	12	—
Other Recruits	7	5

Daily Rate of Pay of Lowest Rank.

	s.	d.
Royal Horse Artillery—		
Gunner	1	4
Driver	1	3
Household Cavalry	1	9
Cavalry of the Line	1	2
Royal Field Artillery—		
Gunner	1	2½
Driver	1	2½
Royal Garrison Artillery—		
Gunner	1	2½
Royal Engineers—		
Sapper	1	1½
Foot Guards	1	1
Infantry of the Line	1	0
Army Service Corps	1	0
Royal Army Medical Corps	1	2
Army Ordnance Corps	1	2
Boys, all corps, until they attain the age of 18	0	8

With an addition, in all corps, of 3d. a day messing allowance on obtaining a certificate of military efficiency from the commanding officer.

The new scheme.

The actual working out of Mr Brodrick's new scheme for having six army corps organized in the United Kingdom had not been promulgated at the time when it was necessary for this article to go to press. It was only known that Aldershot, Salisbury, and Dublin were to be the headquarters of the three active army corps, and Colchester, York, and Edinburgh of what may be called the three sedentary army corps. The scheme had involved much labour, but, even on paper, the detailed distribution of the several units of the army into their brigades, divisions, and army corps, and the definition of the territorial limits of the commanders' authority, did not appear to have reached its final stage. It has, we believe, been decided that there will be one marked difference between the new army corps and those which are known as such on the Continent. In Russia, France, Germany, and Austria the several ranks of senior officers have direct relation to the functions which they fulfil. Normally the army corps is commanded by a general, the division by a lieutenant-general, the brigade by a major-general, the regiment forming an intermediate link between the brigade and the battalion. In England this intermediate link does not exist as a part of the progressive expansion of the army from its smaller to its larger organism. The regiment forms the connecting link between the battalions at home and those abroad, and in some sort between the regular and auxiliary battalions. It is not intermediate between the battalion and the brigade. It appeared, from the indications furnished, to be intended to appoint colonels as brigadier-generals to command the brigades, major-generals to command the divisions, while three full generals (Sir Redvers Buller, Sir Evelyn Wood, and the duke of Connaught) were appointed to the first command of the three active army corps, though, on Sir Redvers Buller's retirement in October 1901 his successor in the command of the 1st Army Corps, Sir John French, was a major-general with the local rank of lieutenant-general. If this be so, the rank of lieutenant-general would virtually disappear from the ordinary course of the military hierarchy during peace time. As experience has shown in South Africa, it becomes a very necessary link in any considerable war, and major-generals have been appointed with "local and temporary" rank as lieutenant-generals accordingly. This step as to the peace organization would have the further importance of greatly limiting the possibility of promoting major-generals during peace time. The royal warrant already referred to makes that promotion dependent upon there being a specific appointment to which the promotion is made. The filling up by major-generals of the specific appointments which in foreign armies are reserved for lieutenant-generals, obviously affects this question very materially, and practically would produce the result that nearly all officers who reached the rank would terminate their career as major-generals.

Two departments, each of which proved during the Boer war to be inadequate for the work assigned to it, have been the subjects of recent and special investigation, viz., the army medical department and the remount department. Experience has shown that the attractions offered by army medical service have not been adequate. Briefly, the new scheme is as follows:—The department is to be administered by an "Advisory Board" of nine members under the chairmanship of the Director-General. Two of these are to be officers of R.A.M.C., two civil physicians, two civil surgeons, one representative of the War Office, one representative of the India Office. It advises on all medical army matters, including promotion of officers, thus superseding the "promotion board," which hitherto has dealt with that subject. The scalo of pay is to be—

	£	s.	d.	
Lieutenant "on probation" and Lieutenant, in all	£323	10	0	per annum.
Captain (after 3 years' total service)	379	15	2	,,
,, ,, 7 ,, ,, ,,	400	0	0	,,
,, ,, 10 ,, ,, ,,	477	15	2	,,
Major ,, 12 ,, ,, ,,	537	12	10	,,
Major (after 3 years as such)	632	12	10	,,
Lieut.-Colonel (after 20 years' service)	713	15	4	,,
,, (selected to an establishment of 50)	804	15	4	,,
Colonel	953	10	10	,,
Surgeon-General	1500	0	0	,,
Director-General	2000	0	0	,,

Candidates must be British subjects of unmixed European blood, under 28 years of age, with good references and a registrable qualification to practise. Provision is made for examinations prior to appointment and promotion to each rank. Previous to each of these the candidate will have the opportunity of attending, partly at Netley, partly at selected civil hospitals, courses of instruction in the special subjects in which he is required to pass. Before promotion to captain and before promotion to major, he may, by passing exceptionally well, obtain an acceleration of promotion varying from 3 to 18 months. Brevet promotion may be given either for distinguished service in the field or other exceptional service not in the field. The creation of an instructional military hospital and military medical staff college is proposed. A retaining fee of £25 per annum is proposed for such medical officers as, after 3 years' service as lieutenants, go to a reserve of officers.

The nursing service is to be called "The Queen Alexandra's Imperial Military Nursing Service," and governed by a board under the Queen as president. The pay ranges from the matron-in-chief, from £250 to £300 per annum (by £10 annual increments), with lodging allowance, to nurses, £25 a year to £35 (by £2, 10s. annual increments). The ranks are principal matrons (from £110), matrons (from £70), sisters (from £37, 10s.), nurses, and female servants.

An almost equally elaborate scheme had been proposed for the reconstruction of the army remount department, but it would appear that financial considerations caused it to be abandoned. No department within the scope of its possibilities accomplished harder or more valuable work during the South African war. (J. F. M.*)

British Colonial Forces.

The British colonial forces proper are those raised and maintained by the colonies at their own expense, either for local purposes or as a voluntary contribution towards imperial defence. The relative prominence of these two objects necessarily depends mainly on the position and population of individual colonies or groups. Canada must maintain a considerable land force for the defence of a long land frontier, while fortunately the chance of hostilities with the United States is sufficiently remote to enable the empire to count on Canadian troops under other conditions. Newfoundland, being little liable to attack and having small financial resources, has not hitherto kept up any military force beyond a few armed police; advantage has, however, now been taken of the exceptional advantages the colony offers as a source of supply of men for the royal navy in war. The Australian states, including New Zealand, derive security from their position against organized invasion so long as British naval supremacy is maintained in Far Eastern waters. Though in a maritime war their land forces would in part be required for protecting their ports against predatory raids, they would doubtless be largely available for offensive operations in aid of imperial strategy. In the West Indies the function of local troops, largely native, must be looked upon as entirely local defence; in Bermuda and Jamaica they are auxiliary to imperial garrisons; in the Leeward Islands, Barbados, Trinidad, British Guiana, and British Honduras, they secure internal tranquillity in peace and guard against any possible raiding attack from a cruiser in war. A small white corps in the Falkland Islands has been raised to serve the latter purpose. In West Africa considerable forces of armed natives are maintained to secure the peaceful administration of the more turbulent parts of Sierra Leone, the Gold Coast, Lagos, and Northern and Southern Nigeria. In St Helena, the eastern colonies of Ceylon, the Straits Settlements, and Hong Kong, colonial volunteers, mainly European or of European descent, form valuable auxiliaries to the regular garrisons of the imperial coaling stations in these colonies. There are also native armed police in the two last, and a Sikh force, maintained by the confederated Malay States, would in war furnish assistance to the Singapore garrison. Armed police in Labuan and Fiji, assisted by white volunteers in the latter colony, maintain order in peace and would resist predatory attack in war. An armed constabulary of Papuans secures the internal quiet of British New Guinea.

In the self-governing colonies the colonial forces are administered by a defence department, which in Canada, Victoria, and New Zealand, is under a minister of defence; in Natal, under the minister of lands and works, and in the other colonies under the prime minister or the chief or colonial secretary. In Canada, West Australia, Queensland, and New Zealand, the forces are commanded by imperial officers lent to the colonial Governments; in South Australia, Victoria, and Tasmania, by officers of the local forces. In Cape Colony and Natal their command in war devolves on the generals commanding the imperial troops. This is also the case in crown colonies where there are imperial troops permanently stationed. In the Leeward Islands, Trinidad, and British Guiana, the militia or volunteer forces are commanded by an officer who has also the armed police of the colony under him, and the same arrangement was proposed for the volunteer force raised for Barbados to replace the imperial troops withdrawn from that island. A few imperial officers, in addition to the commandant, are employed on the headquarters staffs of several of the self-governing colonies, and the frontier forces of West Africa are almost entirely officered from the imperial regular or militia service.

The permanent troops of Canada, corresponding to the regular forces of the imperial army, consist of 2 squadrons of cavalry, 2 field batteries, and 2 garrison companies of artillery, and 4 companies of infantry. The North-West Mounted Police, though enrolled under civil law, are practically a fine military force. The only permanent forces of Cape Colony and Natal are the Cape Mounted Rifles and the Natal Police, who have proved themselves most efficient soldiers. There are armed police organized as a military force in Bechuanaland, Basutoland, and Rhodesia. In Australia and New Zealand the regular troops consist of forces of artillery and engineers, and a small staff of officers and non-commissioned officers for other branches. In the West Indies the permanent forces are armed native police, and in West Africa native constabulary organized on an entirely military basis. There are armed police at the Straits Settlements, Labuan, Hong Kong, Fiji, and British New Guinea, and the Malay States Guides in the Federated Malay States are permanent troops.

The establishments of permanent troops in the different groups of states are approximately as follows:—

North America	1,700
South Africa	3,200
Australasia	2,000
Mediterranean (Cyprus) . . .	700
West Indies	2,800
West Africa	8,000
Eastern colonies	3,400
Total .	21,800

These figures do not include the armed police of the Australian states and of New Zealand, of which certainly the mounted branch could be made available in war, and would be highly efficient as mounted infantry.

The pay of a private soldier in the permanent forces in Canada is 2s. 0½d. (½ dollar) a day. In South Africa it is 5s. or 6s., in New South Wales and Queensland, 2s. 3d., in Victoria, 3s. 6d., and in New Zealand, 5s. or 6s. The native armed police in the West Indies receive at the rate of 2s. to 3s. a day, the frontier forces of West Africa, 1s. or 1s. 3d., and the armed police and constabulary in the eastern colonies from 8d. to 1s.

In Canada, Natal, West Australia, and Queensland, men enlist in the permanent forces for three years, in Tasmania for five, in Cape Colony for five in the first instance, and afterwards for fresh periods of three years at the expiration of each former period, and in Victoria and New South Wales for five years, with the option of re-engagement for a further period of five years. The periods for which natives enlist in the armed police forces of the different West Indian colonies vary from one to six years. It has been proposed to make the term of enlistment in the West African frontier forces a uniform one of seven years, and to encourage re-engagement. Five years is the usual period in the East African colonies.

The colonial forces, apart from the permanent troops dealt with above, comprise the following units of cavalry, mounted infantry, infantry, artillery, and engineers, partially paid and unpaid.

Colony.	Cavalry (Squadrons).	Mounted Infantry (Coys.).	Infantry.		Field Artillery (Btts.).	Garrison Artillery (Coys.).	Engineers (Coys.).
			Btns.	Coys.			
Canada	37	1	59	9	17	31	2
Jamaica	...	.	...	6	..	2	
Leeward Islands		1	...	3			
Trinidad	4	...	...	8			
British Honduras	...	..	...	2			
,, Guiana	...	...	...	4	...		
Falkland Islands	...	..	.	1			
Gold Coast	...	.	..	3			
St Helena	...	...		1			
Cape of Good Hope	...	13	7	9	2		
Natal	...	26	2	...	1		
Ceylon	...	1	..	13	1		
Straits Settlements	...	...	...	.	1		
Hong Kong	...	...	...	1	1		
W. Australia	...	...	...	8	2		
S Australia	...	3	..	18	2	2	
Victoria	...	9	5	10	3	7	1
New S. Wales	2 Regts.	4	8	...	2	4	2
Queensland	...	12	5	2	2	3	
Tasmania	..	.	3	..	...	2	1
New Zealand	...	18	9	9	5	9	5
Fiji	.	...	..	5			

There are also medical services, including officers and men, in Canada, Cape Colony, South Australia, New South Wales, Queensland, New Zealand, and Ceylon. One or two of the colonies have the nucleus of an Army Service Corps.

The establishments of partially paid and unpaid troops in the different groups of colonies are approximately as follows:—

North America	34,700
South Africa	9,800
Australasia	28,600
West Indies	3,000
West Africa	400
Eastern colonies	1,900
	78,400

These numbers, representing approximate peace establishments, are capable, especially in the first three groups, of large expansion in war by the accession of men who, from their ordinary conditions of life, possess considerable military aptitude.

Service in all the forces is at present entirely voluntary, in the sense that there is no man now serving who has been compelled to enrol, but the actual laws governing the forces in Canada, South Australia, Queensland, Tasmania, New Zealand, Jamaica, the Leeward Islands, and British Guiana provide for the ballot, if authorized establishments cannot otherwise be kept up, or in war. In Canada, Cape Colony, and New Zealand, all male inhabitants of fighting age can be called out for a *levée en masse*.

Apart from the permanent troops, the whole of the forces of Canada, Natal (though called volunteers), West Australia, South Australia, Jamaica, and British Guiana, are partially paid, *i.e.*, all ranks receive pay during peace according to the military duties they perform. Those of Cape Colony, Tasmania, New Zealand, the Leeward Islands, Trinidad, British Honduras, the Falkland Islands, St Helena, the Gold Coast, Ceylon, the Straits Settlements, Hong Kong, and Fiji are unpaid, except when called out for active service, though most of the corps receive capitation grants for efficients. In Victoria, New South Wales, and Queensland, though the bulk of the troops are partially paid, there are also unpaid corps. The forces in Jamaica, though termed militia, do not receive pay for the ordinary drills laid down by law. The general tendency of late years has been to substitute partially paid or militia for unpaid or purely volunteer troops, as with the former it is found possible, under the conditions which obtain in most of the colonies, to get greater efficiency than with the latter.

In Canada the daily rate of pay for a militiaman during training is 2s. 0½d. In Natal a volunteer, if mounted, 6s., and if dismounted, 5s. for each day's training. In South and West Australia a man receives 5s. for each of a certain number of paid drills. Militiamen in Victoria, New South Wales, and Queensland, can by attendance at specified parades, and by efficiency earn £6 : 5s., £6 : 8s., and £7 per annum respectively. The daily rate of pay for a militiaman in Jamaica, during continuous training as distinct from ordinary drills, is 2s.

The period of service as laid down in Militia or Volunteer Acts of Canada, Natal, West Australia, Victoria, Queensland, Tasmania, Jamaica, Trinidad, and British Guiana, is three years. In South Australia it is two years in the active force, and three in the reserve. For the Cape and New Zealand it is not less than one year. For New South Wales, and for the colonies not mentioned above, where the local forces are entirely volunteers, no period of service has been laid down, men being allowed to cease serving on giving notice varying from fourteen days to three months.

There is considerable variation in the amount of annual training undergone by the various colonial auxiliary forces. As far as it is provided for by legislative enactment, the average number of days' training in the year is about twelve. In Canada, Queensland, and Tasmania, eight days is laid down as the minimum, and sixteen as the maximum period, but in Queensland the maximum does not include eight days' continuous training which may be ordered by the governor. In South Australia the maximum for the active force is twenty-four days, and the minimum twelve of five hours; for the reserve twelve days' training is required. In New Zealand 168 hours is the maximum. In all the Australasian states the partially paid troops frequently hold voluntary parades. The regulations for the unpaid volunteers in Cape Colony require for efficiency twenty-seven drills in the first year's service, and eighteen in subsequent years; those for the paid volunteers in Natal lay down ten days in camp or twenty-four drills. In Jamaica the Militia Act provides for twelve ordinary drills, in addition to target practice and inspection parades, and in British Guiana for twelve days' drill a year.

All the colonies have already, or are now acquiring, rifles of the same calibre as those used in the imperial army, and the greater number of these rifles are of Lee-Metford or Lee-Enfield pattern. In field artillery there is more diversity, but this is likely to be remedied in the future. With regard to fixed armaments, apart from those provided by the imperial Government at the imperial fortresses and coaling stations, the Governments of Natal, of the six Australian states, and of New Zealand, have mounted powerful guns at their principal ports. British Guiana has defended Georgetown, and Trinidad and Barbados are likely to follow suit when the state of their finances makes it possible for them to do this in addition to maintaining defence forces. Canada has contributed largely to the protection of Esquimalt; and Ceylon, the Straits Settlements, and Hong Kong, to the defended coaling stations in these colonies. For the supply of war material the colonies are still largely dependent on Great Britain, but Canada has a cartridge factory, and shell foundry, and there are private ammunition factories in Australia and New Zealand, capable of manufacturing ammunition for Government small arms.

Colonial naval forces are practically confined to South Australia, Victoria, New South Wales, and Queensland. South Australia owns a protected cruiser, Victoria an armoured turret-ship and five torpedo boats, New South Wales two torpedo boats, and Queensland two gun-vessels and two torpedo boats. To man these ships there are altogether some 200 permanent and 1400 partially paid or unpaid officers and men. In view of the fact that a considerable imperial squadron, to which the Australian states and New Zealand contribute £126,000 annually, is always maintained in Australasian waters, and that the states have also provided by fixed defences against the raiding attacks of cruisers on their ports, it is difficult to say what function is played by the local naval defences of Australia. There is undoubtedly a desire in Australia to make some contribution in *personnel* as well as in money to the naval forces of the empire, and the question as to how this can most effectively be done by men thoroughly trained at sea will require consideration. New Zealand, besides contributing to the imperial navy, keeps up naval volunteers, but these are really military forces trained in the duties of garrison artillery and submarine mining. The preventive service in Canada, which includes some 500 officers and men, cannot at present be looked upon as a fighting force. Arrangements are being made for utilizing the fishermen of Newfoundland for the royal naval reserve. Cape Colony makes an annual money contribution of £30,000 to the imperial navy, free of all conditions. Natal makes a contribution of 12,000 tons of coal. It has also naval volunteers; but these, though they have given proofs of their excellence in manning guns of position, have no sea training, and are more properly included in the military forces of the colony.

The following table shows the colonial military and naval expenditure as taken from the latest estimates and accounts:—

Group.	Colony.	Military and Naval Expenditure.	Population (estimated 31/12/97).	Military and Naval Expenditure per head of Population.	Remarks.
		£		s. d.	
Mediterranean .	Gibraltar	...	20,699		
„	Malta	5,709	177,745	0 6	Contribution.
„	Cyprus	25,990	229,286	2 3	Armed police.
North America .	Canada	502,709	5,185,990	1 11	Permanent and Militia force and North-west Mounted Police.
„ „	Newfoundland	8,275	208,000	0 9	Armed police.
„ „	Bermuda	...	16,096		
West Indies .	Bahamas	2,000	52,000	0 9	Armed police.
„ „	Jamaica	67,401	706,394	1 11	Armed police, Militia, and allowance to Imperial troops.
„ „	Leeward Islands	11,235	129,751	1 8	Armed police and defence force.
„ „	Windward Islands	9,500	154,543	1 2	Armed police.
„ „	Barbados	23,972	190,000	2 6	Armed police and allowance to Imperial troops.
„ „	Trinidad	57,689	275,363	4 2	Armed police and Volunteers.
„ „	British Honduras	6,863	34,277	4 0	„ „
„ „	„ Guiana	54,296	286,484	4 0	Armed police and Militia.
„ „	Falkland Islands	150	2,050	1 0	Volunteers.
West Africa .	Gambia	4,616	13,057	8 4	Armed police.
„ „	Sierra Leone	24,299	No trustworthy statistics at present available for these colonies.	...	Armed constabulary and allowance to Imperial troops.
„ „	Gold Coast	53,163		...	Armed constabulary and Volunteers.
„ „	Lagos	35,049		...	Armed constabulary.
„ „	Southern Nigeria	45,077		...	„ „
„ „	Northern „	...		...	Expenditure on armed constabulary at present covered by grant from Imperial Exchequer.
„ „	St Helena	95	3,897	0 6	Volunteers.
South Africa .	Cape of Good Hope	309,504	2,143,100	2 10	Cape Mounted Rifles; Volunteers; contribution to Navy and allowance to Imperial troops.
„ „	Natal	117,452	811,189	2 10	Natal police, Volunteers; contribution to Navy and allowance to Imperial troops.
„ „	Basutoland	13,137	250,000	1 0	Armed police.
„ „	Bechuanaland	...	...	...	£49,425 covered by grant from Imperial Exchequer.
„ „	Rhodesia	238,487	...	...	Armed police and Volunteers (British South Africa Company).
„ „	Mauritius	27,630	377,856	1 5	Contribution and allowance to Imperial troops.
Asia . . .	Ceylon	145,399	3,298,342	0 10	Volunteers, contribution, and allowance to troops.
„	Straits Settlements (including Malay States)	142,266	1,175,656	2 4	Malay States Guides, armed police, Volunteers, and contribution.
„	Labuan and British North Borneo	(not known)	...	...	Armed police.
„	Hong Kong	88,321	248,710	7 1	Armed police, Volunteers, and contribution.
Australasia .	West Australia	16,635	155,749	2 1	Military forces and contributions to Navy, and to Federal fortresses in Australia.
„	South Australia	82,776	361,045	1 9	Military and Naval forces, contributions to Navy and to Federal fortresses in Australia.
„	Victoria	179,392	1,176,268	3 0	
„	New South Wales	233,997	1,335,800	3 6	
„	Queensland	94,401	484,700	3 10	
„	Tasmania	13,996	171,719	1 7	Military forces and contribution to Navy.
„	New Zealand	169,914	768,910	4 5	„ „ „
„	Fiji	2,283	121,798	3 4	Armed police and Volunteers.
„	British New Guinea	3,044	3,350,000	...	Armed police.

Besides Colonial forces proper there are what are officially known as Colonial corps, consisting of troops raised in the Colonies and India, and paid by the Imperial Government for garrison duty at the Imperial fortresses and coaling stations. The Colonial corps at the present time comprise the West India regiment (three battalions), West African regiment, British Central African regiment, Hong Kong regiment, and Chinese regiment; the Royal Malta artillery, the West Indian, West African and East African companies of artillery, submarine miners, and fortress engineers; the Royal Malta militia, the Bermuda militia artillery; and the Bermuda volunteer rifle corps. These corps number altogether some 10,000 regular, 2500 militia, and 300 volunteer troops, and are under the direct control of the War Office. In addition to these Colonial corps under the War Office there are certain other troops of the Empire which also, not being properly Colonial forces, call only for brief mention. These are the military forces of the British Central Africa, British East Africa, Uganda and Somaliland Protectorates. They number altogether some 4500 regular native soldiers, under Imperial officers lent by the War Office, and are administered by the Foreign Office. (M. N.)

INDIA

After the transfer of the Government of India to the Crown in 1858, the whole military organization was recast. The local European army was abolished. The artillery became wholly British, with the exception of a few native mountain batteries. The Company's European artillery, engineers, cavalry and infantry were amalgamated with the royal army. The total strength of the British troops, all of the royal army, was largely increased, while that of the native troops was largely diminished. Three distinct native armies—those of Bengal, Madras, and Bombay—were still maintained. The reduced Indian armies consisted of cavalry and infantry only, distributed as follows, with a few artillery:—

	Battalions, Infantry.	Regiments, Cavalry.
Bengal	49	19
Madras	40	4
Bombay	30	7
Punjab force	12	6
Total	131	36

There were also three sapper battalions, one to each army.

The Punjab force, which had 5 batteries of native artillery attached to it, continued under the Punjab Government. In addition, the Hydrabad contingent of 4 cavalry, 6 infantry regiments, and 4 batteries native artillery, and a local force in Central India of 2 regiments cavalry and 6 infantry, were retained under the Government of India. After all the arrangements had been completed the army of India consisted of 62,000 British and 125,000 native troops.

The Company's military college at Addiscombe was closed in 1860, and the direct appointment of British officers to the Indian local forces ceased in 1861. In that year a staff corps was formed by Royal Warrant in each Presidency "to supply a body of officers for service in India, by whom various offices and appointments hitherto held by officers borne on the strength of the several corps in the Indian forces shall in future be held." Special rules of pay, pension, and promotion were laid down; the principle of the last being promotion by length of service in the various ranks from second lieutenant up to lieut.-colonel. The corps was at first recruited partly from officers of the Company's service and partly from the royal army, holding staff appointments (the new regimental employment being considered as staff duty) and all kinds of political and civil posts; afterwards by young officers from the British service, and recently in addition by second lieutenants drafted direct from the Royal Military College, Sandhurst. The native artillery and sappers and miners were to be officered from the Royal Artillery and Royal Engineers. The only English warrant and non-commissioned officers now to be employed in the native army were to be those of the Royal Engineers with the sappers and miners. Officers of the old Indian army who did not accept service in the artillery, engineers, and new line regiments transferred to the British army on the amalgamation, remained in their former cadres for promotion. Now all have disappeared from the active list except a few generals.

A radical change in the regimental organization of all the native armies was effected in 1863. The Punjab Frontier Force was from the first organized on the irregular system, which was there seen at its best, as also were the new regiments raised during the Mutiny. This system was now applied to the whole army, each regiment and battalion having seven British officers attached to it for command and administrative duties, the immediate command of troops and companies being left to the native officers. Thus was the system reverted to which was initiated by Clive, in the early days, of a few British officers only being attached to each corps for the higher regimental duties of command and control. Time had shown that this was more effective than the regular system instituted in 1796 of British officers commanding troops and companies.

Selection for all regimental commands was now the order. A new spirit was breathed into the army. The supremacy of the commandant was the main principle. He was less hampered by the unbending regulations enjoined upon the old regular regiments, had greater powers of reward and punishment, was in a position to assume larger responsibility and greater freedom of action, and was supported in the full exercise of his authority. The system made the officers.

Up to 1881 the native army underwent little change, but in that year financial considerations prevailed and 18 regiments of infantry and 4 of cavalry were broken up, while the rank and file of the rest were increased. Almost the same number of men were maintained as before, but in fewer and stronger regiments and better organized for war. The only reduction made in the British troops was in the Royal Artillery, which was diminished by 11 batteries. The events of 1885, however, on the Russo-Afghan frontier led to an augmentation of the army. The 11 batteries Royal Artillery were brought back from England, each of the 9 British cavalry regiments in India received an addition of a fourth squadron; each of the British infantry battalions was increased by 100 men and 3 battalions were added. The native cavalry had a fourth squadron added to each regiment; three of the four regiments broken up in 1881 were re-raised, while the native infantry was increased in regimental strength, and 9 new battalions raised composed of Gurkhas, Sikhs, and Punjabis. The addition in all amounted to 10,600 British, and 21,200 native troops. In 1890 the strength of the army of India was 73,000 British, and, including irregulars, 147,500 native troops.

Many important changes have taken place since 1885, which have vastly improved the efficiency of the native army. Seven Madras infantry regiments were converted into regiments for local service in Burma, composed of Gurkhas and hardy races from Northern India; six Bengal and Bombay regiments were similarly converted into regiments of Punjabis, Pathans, and Gurkhas; the native mountain batteries have been increased to ten; the system of linked battalions has been introduced with the formation of regimental centres for mobilization; and reserves for infantry and mountain artillery have been formed. The number of British officers present with each regiment has been increased to nine, and the two wing commands in battalions have been converted into four double-company commands of 250 men each, under a British commander, who is responsible to the commandant for their training and efficiency, the command of the companies being left to the native officers. This system, which is analogous to the squadron command in the cavalry, admits of closer individual attention to training, and distributes among the senior British regimental officers effective responsibility of a personal kind.

An addition to the army of five native battalions at the expense of the imperial Government was made in 1900 as the result of India being called upon to furnish garrisons for Mauritius and other colonial stations over sea. These new battalions are raised from such warlike and hardy races as Sikhs, Punjabi Mahommedans, Jats, and hillmen in Northern India. Of these three are included in the Punjab army, and two in that of Bengal.

The unification of the triplicate army departments in the different Presidential armies was completed in 1891, all being brought directly under the supreme Government; and the three separate staff corps of Bengal, Madras, and Bombay were fused into one in 1891 as the Indian Staff Corps. These measures prepared the way for the new system of army organization, which, by authority of Parliament, abolished divided control and placed the whole army of India under the Governor-General and the Commander-in-Chief in India.

On the 1st April 1895 the army of India was divided into four great commands—Punjab, Bengal, Madras, Bombay. These commands are under lieutenant-generals, styled as commanding the forces therein, all under the direct command of the Commander-in-Chief, and the control of the Government of India. The Punjab command includes the whole of the Punjab province. The Bengal command includes the territories under the civil governments of Bengal, Assam, the North-West Provinces and Oude, and part of the Central Provinces. The Madras command includes the Madras Presidency, Burma, and the Belgaum district. The Bombay command includes the Bombay Presidency, Baluchistan, and parts of Rajputana, Central India, and the Central Provinces.

The two local cavalry regiments and six battalions in Central India are now included in the Bengal and Bombay commands. The Hydrabad contingent remains as a separate force under the direct orders of the Government of India. It is commanded by a general officer and garrisons a district of the Hydrabad state, but is available for general service.

The unified army is now organized on the territorial principle. The old Madras and Bombay armies are included in the Madras and Bombay commands, and recruit with some exceptions within the territories of these commands. The Bengal army was divided into two parts. All that portion of it which recruits in the Punjab is included in the Punjab command, while that which recruits in North-West India and neighbourhood is included in the Bengal command. The Gurkha battalions, a foreign element, are divided between the Punjab and Bengal commands with one battalion in Burma. All the troops, though they have a home connexion with their particular commands, are interchangeable and liable to serve anywhere in and outside India.

The composition of the several commands is as follows:—

Indian Army.

Native Troops.	Punjab.	Bengal.	Madras.	Bombay.	Hydrabad Contingent.	Total.
Cavalry regiments	15	11	3	7	4	40
Artillery batteries (10 mountain)	7	2	...	2	4	15
Sappers and miners	...	1	1	1	..	3
Infantry battalions	44	26	32	31	6	139
Strength, including officers	52,600	32,900	30,300	31,200	7,600	154,600

The Indian Staff Corps, consisting of a corps of British officers for regimental employment in the native army, for staff, departmental, and other duties, numbers at present 2600 effectives, with a tendency to increase. Of these 26 are general officers.

The Indian Medical Service numbers 700 officers of all ranks, with a subordinate establishment of 500 military assistant surgeons.

The present establishment of British troops in India numbers 73,500. They are periodically relieved from home, the tour of service varying from 9 years for cavalry up to 15 years for artillery and infantry; and are generally distributed in the several commands as follows:—

	Punjab.	Bengal.	Madras.	Bombay.	Total.
Cavalry regiments . .	3	3	2	1	9
Artillery horse batteries .	4	3	2	2	11
,, field batteries .	8	14	8	12	42
,, heavy batteries .	2	1	1	...	4
,, mountain batteries	5	...	1	2	8
,, garrison batteries .	3	8	3	9	23
Infantry battalions . .	15	17	8	11	51

Royal Engineers, Submarine Miners, etc., one company in the commands.

The regular troops, British and native together, number 228,100, the strength of the several arms being as follows:—

	British.	Native.	Total.
Cavalry	5,600	24,700	30,300
Infantry . . .	52,600	122,000	174,600
Artillery . . .	13,400	3,200	16,600
Guns.	390	76	466

The Native Army Active Reserves, mainly infantry, are growing, and at present number about 21,000, nearly half of whom belong to the Punjab command. They consist of men who have served with the colours from five to twelve years, and are called out annually for one month's training at regimental centres. There is also a large garrison reserve of all arms, consisting of old soldiers who have served twenty-one years, and are on the pension establishment.

The auxiliary forces consist, in round numbers, of

Volunteers (British)	31,000
Imperial Service Troops (Native)	18,000
North-West Frontier Irregular Corps (Native) . .	5,000
Burma and Assam Military Police Battalions (Native)	15,000

The volunteers are drawn from the British element of the population: organized in corps in the different commands—rifles, mounted and foot, light horse, and artillery—under district general officers. Well armed and trained, they are of great defensive value.

The Imperial Service Troops came into existence in 1888, when the principal feudatory chiefs spontaneously offered men and money towards co-operation in imperial defence. Portions of their forces, under the instruction of a staff of British inspecting officers, have been raised to such a pitch of general efficiency as to fit them to take a place in line with the army of India. At present they consist of 8000 cavalry, 8000 infantry, with pioneers, mountain artillery, camel and transport corps, and have done good service in the field at Gilgit, on the Punjab frontier, and in China. They are under the orders of the Government of India.

The North-West Frontier Irregular Troops are organized in eight corps as rifles and militia, under two and three British officers to each corps, and form an efficient advanced frontier force for service in the tribal countries beyond the administrative border. They are under the political authorities of the frontier province, and are recruited from the Afridi and other mountain clans along the border.

The Burma and Assam Military Police are organized in battalions under British officers, seconded from their regiments for this duty. They are recruited from the best material in the Punjab and neighbourhood, and form a very efficient irregular force for service on the eastern frontiers. They are under the provincial civil governments.

The supreme military power in India is vested by law in the Governor-General in Council, subject to the control of the Secretary of State for India. The business of the army is conducted through the military branch of the Government secretariat, which is immediately under the military member of Council. The secretary of this branch, like all the others, holds a position somewhat above that of an under-secretary of state in England as, apart from his responsibility to the military member, the duty rests with him of personally bringing to the knowledge of the Viceroy every matter of special importance. The executive head of the army is the Commander-in-Chief in India. He is responsible for its efficiency, is the adviser of Government in all military matters, and is an extraordinary member of Council with a voice in it, and precedence next after the Viceroy. Besides the great department of command and discipline of which he is the head, there are various army departments, for the most part spending—ordnance, works, accounts, commissariat-transport, Indian medical service, army remount, clothing. These, together with what comes up from the Commander-in-Chief, make up the whole business of the army, and are administered in the military department of the Government by the military member of Council. All orders are issued by the secretary of this department in the name of the Governor-General in Council.

The Commander-in-Chief nominates to all appointments in the combatant branches subject to regulations, the action of Government being limited to confirming his nominations, which in all important cases are the result of communications which obtain the Viceroy's approval beforehand. The military member nominates to all appointments in the departments under him. As a matter of fact, the disposal of questions of equipment, armament, and defence, is the result of deliberation between the two authorities previous to submission to the supreme authority. Communication between the Commander-in-Chief and the military department is carried on through the adjutant-general and quartermaster-general. The Commander-in-Chief has under him a personal office, of which his military secretary is head, dealing with appointments and promotion. Also under him is the adjutant-general's department, which includes the inspector-generals of royal artillery and cavalry, staff officers for musketry and royal engineers, &c., with the quartermaster-general's department, including mobilization, intelligence, army signalling, &c. Other heads at army headquarters are the surgeon-general, army and Indian medical staff, director military education, judge-advocate-general, principal veterinary officer.

The division of the army into four great commands with complete army and departmental staff, all under lieutenant generals, vested with large responsibilities and powers, has relieved the Commander-in-Chief of much detail, and left him free to exercise general supervision over the army—to watch it in peace and direct it in war, and to consider the important military questions of the day. Comprised in the commands are thirty military districts. All the general officers and staff are selected according to a fixed proportion from both services, British and Indian.

The establishment of units of the British army in India is:—

Cavalry: 29 officers, 601 other ranks—total 630, in 4 squadrons.
Artillery, horse and field: 5 officers each, 157 other ranks—total, 162.
,, mountain: 5 officers, 106 other ranks—111.
,, heavy: 5 officers, 95 other ranks—100.

Artillery, garrison: 5 officers, 140 other ranks—145.
Infantry battalion: 29 officers, 1003 other ranks—1032, in 8 companies.

The peace establishment of the Indian cavalry regiment is 11 British officers, 17 native officers, 608 other ranks—total 636, organized in 4 squadrons. Their armament is sword, lance, and Lee-Enfield carbine. Of the 40 cavalry regiments 25 are lancers. The British officers in each regiment fill the grades of commandant, squadron commanders (one of them second in command), adjutant, and squadron officers. Native officers are in command of half squadrons, and one of them is native adjutant as assistant to the British adjutant. That of the infantry battalion is 11 British officers, 16 native officers, other ranks 896—total 923, organized in 8 companies under native officers, and in 4 double companies under British officers. The British officers fill the grades of commandant, double-company commanders (one of them second in command), adjutant, quartermaster, and double-company officers. One of the native officers is native adjutant. The armament is the Lee-Enfield rifle. There are 9 battalions of pioneers, trained and armed as infantry, and instructed as pioneers, with a special equipment. The 3 corps of sappers and miners are organized in companies. They are armed as infantry and trained and equipped as engineers. They vary in strength; that of Bengal being 20 officers Royal Engineers, with 31 warrant and non-commissioned officers, 23 native officers, other ranks, 1414—total, 1488: that of Madras, 22 officers and 34 warrant and non-commissioned officers R.E., 24 native officers, 1490 other ranks—total, 1570: that of Bombay, 14 officers and 20 warrant and non-commissioned officers R.E., 15 native officers, 886 other ranks—total 935. The R.E. officers fill the grades of commandant, superintendents, instruction, park and train, adjutant, company commanders, and company officers. The native mountain battery consists of 4 officers Royal Artillery, 3 native officers, 253 other ranks—total, 260. They are armed with 2·5" guns. All army accoutrements are of brown leather manufactured in India. The grades of the cavalry native officers are risaldar-major (one to each regiment), risaldars and ressaidars in command of troops, and under them jemadars; those in the infantry are subadar-major (one to each battalion), subadars in command of companies, and under them jemadars. Promotion is made by selection. Selected non-commissioned officers are promoted to the commissioned grades, and direct commissions are also given to native gentlemen of rank and position, who are required to serve a probationary period before confirmation. Many members of old military aristocratic families serve in the ranks in order to win a commission.

The full dress of the Indian army varies in colour—red, blue, dark green, and drab. The fighting and working dress of all is of "khaki" colour. Khaki uniform, which has now been adopted in the imperial army, was used first by the Punjab Frontier Force in 1849. It developed during the campaign in India in 1857, and became general during the Afghan war. The word is derived from the Persian "khak," meaning dust, ashes.

A medical officer of the Indian Medical Service is permanently attached to each corps. The establishment of British officers includes absentees on leave. All appointed to the staff or other duty for a term of years, are seconded in their regiments. Their army rank is regulated by substantive rank in the staff corps or by brevet. The temporary rank of lieutenant-colonel is given to a major selected for the appointment of commandant, and that of major to a captain for that of second in command. The principle which it is endeavoured to preserve is that none but approved British officers should be appointed to native regiments. They are first trained and tested in British regiments before appointment to the staff corps.

Annual field-training is carried out first by squadrons and double companies under their own commanders, followed by that of the regiment, and of larger bodies of the combined arms at every station where available. Camps of exercise are a great feature in India, where unrivalled facilities exist close at hand for training the troops in every kind of country, which are taken full advantage of. Musketry is a strong point in the training. The course is a very practical one, and the result is that the Indian soldier soon develops into a first-class shot.

Recruiting is conducted by British recruiting staff officers at various centres throughout the commands, and also at regimental headquarters where men offer themselves, particularly cavalry. Subject to certain restrictions as to active service, a man may claim his discharge after three years' service, but it is optional with him to serve on for pension, or to pass to the reserve after five years' service. The army draws its recruits as a rule from the peasant or yeoman class, men of good physique, hardy, enduring, and courageous. There is no lack of them. The service is very popular and well paid, and has a liberal system of pensions for long service and wounds, and also family pensions for widows or orphans in case of death on active or foreign service, an attractive feature which appeals to the homes. It would be difficult in any country to find finer fighting material than that furnished by Gurkhas, Sikhs, Pathans, Rajputs, and Jats, men who have on many a field stood shoulder to shoulder with the best and bravest of the British force. There is hardly any practical limit to the number of excellent soldiers that in case of necessity can be raised at short notice from the martial races of India, who possess great aptitude for military training.

The Indian army is heterogeneous as a whole but homogeneous in its units. The variation in race of these units is great. About one-third of the regiments are composed of one class—tribe, caste, or religion—such as Gurkhas, Sikhs, Rajputs, Jats, Mahommedans, hillmen, &c., while the rest are composed of class squadrons and companies of the above and other races. Their languages differ, but there is one common to all which they soon acquire—the Oordoo or Hindustani—the language of the camp or *lingua franca* of India, which originated with the old-time Mahommedan invasions of India, and is a mixture of Persian, Arabic, and Hindi. It is obligatory upon all staff corps officers to pass in Hindustani, and upon the regimental officer to pass in the language peculiar to the men in his regiment.

In India the transport and supply services are termed the commissariat-transport department. It is under the control of a commissary general-in-chief (a major-general) who has directly under him a commissary-general for transport only. Each command has a commissary-general. Under them are assistant and deputy assistant commissary-generals. All these appointments are held by Indian staff corps officers. This department feeds and clothes the army in the field, and the British troops in quarters. All native troops in India during peace are independent of the commissariat for food and forage, making their own arrangements regimentally, as their pay includes the provision of these items. The transport consists of corps of mules and camels, trains of pony and bullock carts, with elephants for special work. Regiments and corps on the mobilization roster keep in charge a proportion of mule transport.

The ordnance department, under a director-general of ordnance (a major-general), is officered from the Royal Artillery. There is an inspector-general to each command. The military works services, under a director-general (a major-general), is officered from the Royal Engineers. There is a chief engineer in each command.

The organization for war is by brigades and divisions. Regiments and batteries on the mobilization roster are required to keep up a special equipment for field service, and on receipt of orders to mobilize know precisely what to do. Besides the divisions (four) which are always maintained in a state of readiness, there are other troops specially detailed for the lines of communication. When regiments move in course of relief to stations outside the mobilization area, their place in the list is taken by the relieving corps to which they make over their special equipment.

The number of the military forces of the many native states of India, great and small, is now returned at 90,000, mostly ill-armed and ill-trained, one-third of which are cavalry. This total does not include the 18,000 well armed and organized imperial service troops furnished by twenty-three of these states. Kashmir has a force of Dogra Rajput infantry, hardy, inured to hill marching, and valuable in protecting the far north corner of that state about Gilgit and Chitral. A considerable part of the Gwalior and Hyderabad forces is fairly well drilled, and possesses some equipped batteries of artillery. The Sikh states have good Sikh troops, well drilled and fairly officered. They are very loyal to their chiefs. Rajputana could supply a large force of cavalry, all members of a military class. There is much excellent material among these troops which, under the hands of British officers, could be made useful in escort duty and keeping open lines of communication. Among the states guns abound of all sorts, sizes, and conditions. They may be put down at 500, all smooth-bores of old pattern, half of them movable. Very little of their artillery is organized.

Nepal is not included in the native states of India. It pays no tribute. This mountainous state, the homeland of the Gurkhas, has maintained close and friendly relations with the Indian Government since the accession to power of the Jung Bahadur in 1846, especially after he had, to use his own expression, "stood on London Bridge." In 1857 he personally led a strong Gurkha force of infantry and artillery to co-operate with the British army at Lucknow. Nepal has an army of 48,000 infantry, capable of expansion, and about 600 guns of various kinds.

The maintenance of the 18,000 imperial service troops costs the states concerned about £420,000, the outlay of the Indian Government on them for inspection being £14,000.

The personal cost of the British garrison of India to Indian revenues is about £4,400,000 a year, while the net expenditure of the whole army of India is about 15½ millions. (J. J. H. G.)

THE UNITED STATES.

The regular army of the United States has always been small. During the Civil War the several States furnished over 2,800,000 men, organized into volunteer regiments bearing State designations. The officers, except general and staff officers, were appointed by the Governors of the respective States. The maximum authorized strength of the regular army never, during the war, exceeded 40,000 men; and the number in the field, especially towards the close of the war, was very much less. The States, in order to obtain men to fill their quotas, offered liberal bounties to induce men to enlist, and it therefore became very difficult to obtain recruits for the regular army, for which no bounties were given. The regular regiments accordingly dwindled away to skeletons. The number of officers present was also much reduced, since many of them, while retaining their regular commissions, held higher rank in the volunteer army. After the close of the Civil War the volunteers were mustered out; and by the Act of Congress of 28th July 1866 the line of the army was made to consist of 10 regiments of cavalry of 12 troops each, 5 regiments of artillery of 12 batteries each, and 45 regiments of infantry of 10 companies each. The maximum enlisted strength was 51,605. The Act of 3rd March 1869 reduced the number of infantry regiments to 25 and the enlisted strength of the army to 35,036. This was still further reduced, without change in organization, to 32,788 in 1870 and to 25,000 in 1874. The latter number remained the maximum for twenty-four years. The number allotted to a regiment of cavalry, artillery, or infantry was published in orders, and was changed from time to time to meet the needs of the service.

In March 1898 the artillery was increased by 2 regiments, and in April 2 companies were added to each infantry regiment, giving it 3 battalions of 4 companies each. The strength of batteries, troops, and companies was increased, the maximum enlisted strength reached during 1898 being over 63,000. A volunteer army was also organized. Of this army, 3 regiments of engineer troops, 3 of cavalry, and 10 of infantry were United States volunteers, all the officers being commissioned by the President. The other organizations came from the States, the officers being appointed by the respective Governors. As fast as they were organized and filled up, they were mustered into the service of the United States. The total number furnished for the war with Spain was 10,017 officers and 213,218 enlisted men. All general and staff officers were appointed by the President. Three hundred and eighty-seven officers of the regular army received volunteer commissions. After the conclusion of hostilities with Spain, the mustering out of the volunteers was begun, and by June 1899 all the volunteers, except those in the Philippines, were out of the service. The latter, as well as those serving elsewhere, having enlisted only for the war, were brought home and mustered out as soon as practicable.

The Act of 2nd March 1899 added 2 batteries to each regiment of artillery. On 2nd February 1901 Congress passed a Bill providing that the regular army, including existing organizations, should consist of 15 regiments of cavalry, a corps of artillery, 30 regiments of infantry, 1 lieutenant-general, 6 major-generals, 15 brigadier-generals, an adjutant-general's department, an inspector-general's department, a judge-advocate-general's department, a quartermaster's department, a subsistence department, a medical department, a pay department, a corps of engineers, an ordnance department, a signal corps, the officers of the record and pension office, the chaplains, the officers and enlisted men of the army on the retired list, the professors, corps of cadets, the army detachments and band at the United States Military Academy, Indian scouts as now authorized by law, and such other officers and enlisted men as might be thereinafter provided for.

The head of the military establishment is the Secretary of War, a member of the Cabinet. The supply, payment, and recruitment of the army, and the direction of the expenditure of the appropriations for its support, are by law entrusted to him. He exercises control through the bureaus of the War Department. The lieutenant-general commands the army, but all the supply departments are independent of him, and are directly under the Secretary. Promotion to the grade of brigadier-general is by selection, generally, but not necessarily, from the list of colonels. Promotion from brigadier- to major-general, and from major-general to lieutenant-general, is also by selection, though the senior is usually selected. The officers of the various staff departments had previously been permanent. Each had as its head a brigadier-general, selected from the officers of the particular department or corps. Promotion to colonel was by seniority in the department or corps.

The Act of 2nd February 1901 provided that, so long as there should remain any officers holding permanent appointments in the adjutant-general's department, the inspector-general's department, the quartermaster's department, the subsistence department, the pay department, the ordnance department, and the signal corps, they should be promoted, according to seniority, in the several grades, and whenever a vacancy should thereafter occur, it should be filled by detail from the same grade in the line of the army, the length of the detail being four years. Any such officer, below the rank of lieutenant-colonel, who shall have served four years in the staff, is not again eligible for detail until he shall have served two years in the line. When a vacancy occurs in the position of chief of any staff corps or department, the President may appoint to such vacancy an officer of the army at large, not below the rank of lieutenant-colonel, and such officer, while holding said position, shall have the rank, pay, and allowances formerly provided for the chief of the corps or department. Appointments to the lowest grade in the judge-advocate's department are made from the army or from civil life; in the engineer corps, from the Military Academy at West Point, or by transfer of lieutenants of the line after examination; in the medical department, from civil life.

The *adjutant-general's department* is the bureau of orders and records of the army. Orders and instructions emanating from the War Department or army headquarters, and all general regulations, are communicated to troops and individuals in the military service through the adjutant-general. His office is the repository for the records of the War Department which relate to the personnel of the permanent military establishment and the militia in the service of the United States, to the military history of every commissioned officer and soldier thereof, and to the movements and operation of troops. The adjutant-general is charged, under the direction of the Secretary of War, with the management of the recruiting service, the collection and classification of military information in regard to the United States and foreign countries, the preparation of instructions to officers detailed to visit encampments of militia, and the digesting, arranging, and preserving of their reports. The sphere of inquiry of the *inspector-general's department* includes every branch of military affairs except when specially limited in regulations or orders. Inspectors-general and acting inspectors-general exercise a comprehensive and general observation within their respective districts over all that pertains to the efficiency of the army, the condition and state of supplies of all kinds of arms and equipments, the expenditure of public property and moneys, the condition of accounts of all disbursing officers of every branch of the service, and the conduct, discipline, and efficiency of officers and troops; and they report with strict impartiality in regard to all irregularities that may be discovered. They make such suggestions as may appear to them practicable for the cure of any defect that may come under their observation. The *judge-advocate-general's department* is the bureau of military justice. The judge-advocate-general is the custodian of the records of all general courts-martial, courts of inquiry, and military commissions, and of all papers relating to the title of lands under the control of the War Department. The officers of this department render opinions upon legal questions when called upon by proper authority. They act as prosecutors in important military trials, and sometimes represent the Government when cases affecting the army come up in civil courts. The *pay department* has charge of the supply and distribution of and accounting for funds for the payment of the army, and such other financial duties as may be specially assigned to it. The staff departments above enumerated have no enlisted personnel. The *quartermaster's department* is charged with the duty of providing means of transportation of every character, either under contract or in kind, which may be needed in the movement of troops and material of war. It furnishes all public animals employed in the service of the army, the forage consumed by them, waggons and all articles necessary for their use, except the equipment of cavalry and artillery. It furnishes clothing, camp and garrison equipage, fuel, barracks, storehouses, and other buildings; constructs and repairs roads, railways, bridges; builds and charters ships, boats, docks, and wharves needed for military purposes; and attends to all matters connected with military operations which are not expressly assigned to some other bureau of the War Department. Subsistence, ordnance, signal, medical, and hospital stores are procured and issued by other bureaus of the War Department, but the quartermaster's department transports them to the place of issue and provides storehouses for their preservation until consumed. The *subsistence department* has charge of the purchase, inspection, storage, and issue of food supplies for troops. It has one function which, especially at isolated posts, has been found very beneficial, and which is not common to other armies. It keeps for sale at cost to officers and men, in addition to the ration, a large list of other stores. The ration is abundant. Its composition is fixed by the President. In order to obtain variety and meet the necessities of varying climates, such parts of the ration as are not desired are, under direction of company commanders, sold back to the subsistence department at cost, and funds are thus provided for the purchase of articles of diet not included in the ration. The men's messes are improved through another agency, the post exchange. This has been in existence but a few years. It is practically a soldiers' club, under the supervision of officers, in which many articles desired by the men are sold. The profits are periodically distributed among the organizations serving at the post for the improvement of the messes. The enlisted personnel of the subsistence and quartermaster's departments consists of a number of sergeants appointed, after examination, from the line. Clerks, teamsters, labourers, &c., are furnished by temporary detail from the troops or by hire of civilians. The *medical department* is charged with the duties performed by the medical staff in all armies. It has charge of hospitals both at stations and in the field, of ambulances, and of hygiene. It has an enlisted personnel, as large as may be deemed necessary, in addition to the authorized strength of the army. This force is called the hospital corps, and performs all hospital service in garrison and in the field. Its non-commissioned officers, termed hospital stewards and acting hospital stewards, are appointed after examination. A knowledge of pharmacy is required. There is also a nurse corps (female) consisting of one superintendent and such number of nurses as may be needed. The surgeon-general is authorized to employ, under contract, dental surgeons, not to exceed thirty in number. The officers, in addition to their other duties, give instruction by lectures and practical demonstration on "First Aid to the Injured" to all lieutenants of the line and to such captains as may volunteer. Company officers in turn are required to give this instruction to their men four hours a month. There is thus always in every company a number of men able to supplement the work of the hospital corps in the field, or to give the first cares to the wounded in the absence of medical attendance. The *signal corps* is charged with the construction, repair, and operation of military telegraph lines, with the supervision of such instruction in military signalling and telegraphy as may be prescribed by the War Department, and with the procurement, preservation, and distribution of the necessary supplies. A line officer is appointed signal officer at each military post, and supervises instruction, which must be continued until there are in each company at least 1 officer and 4 enlisted men proficient in signalling by flag, torch, and heliograph. The signal corps has an enlisted personnel of 760, of which number 350 are non-commissioned officers. The duties of the *corps of engineers* comprise reconnoitring and surveying for military purposes, selection of sites and formation of plans and estimates for military defences, construction and repair of fortifications and their accessories, planning and superintending of defensive or offensive works of troops in the field, examination of routes of communications for supplies and for military movements, and construction of military roads and bridges, execution of river and harbour improvements assigned to it, and such other duties as the President may order. There are three battalions of engineer troops. They form a part of the line of the army, and are officered by officers of the engineer corps assigned temporarily. The principal engineer station is Willets Point, New York Harbour, where there is an engineer school of instruction. A field officer of engineers commands the station and school. The captains, in addition to performing the routine duties of a military post, act as instructors. Lieutenants of engineers, after serving for about a year after graduating at West Point, are assigned to companies, and constitute the class. The course lasts two years, and comprises instruction supplementary to that given at West Point, where the same subjects are studied, in military and civil (including electrical) engineering, and in astronomical work. The *ordnance department* is charged with the duty of procuring, by purchase or manufacture, and distributing the necessary ordnance and ordnance supplies for the Government, and establishes and maintains arsenals and depots for their manufacture and safekeeping. Infantry small-arms, carbines, swords, sabres, horse equipments, field-gun carriages, and most of the accoutrements, such as haversacks, knapsacks, canteens, &c., are manufactured at the various arsenals. Cannon of all calibres are constructed by the ordnance department, the rough forgings being furnished by private firms. Powder is purchased, but the cartridges are made at an arsenal. Revolvers are purchased. Most of the sea-coast gun-carriages and sea-coast mortars are made by private firms. The ordnance department has a proving ground at Sandy Hook, New York Harbour, where experiments are made and guns are tested. The *record and pension office* has but two officers. It has in charge the records of all volunteers, not only of those who served in the war with Spain, but in former wars. The *chaplains* are of various religious denominations. One is allowed to each regiment of infantry and cavalry, and twelve to the artillery corps.

An officer of engineers or ordnance, or of the adjutant-general's, inspector-general's, judge-advocate-general's, quartermaster's, or subsistence department, or of the signal corps, though eligible to command according to his rank, shall not assume command of troops unless put on duty under orders which specially so direct by authority of the President. An officer of the pay or medical department cannot exercise command except in his own department, but by virtue of his commission he may command all enlisted men like other commissioned officers.

When the United States adopted a policy of liberal appropriations for sea-coast defence, the need was felt of a single body of experts to decide upon what was needed and how the money should be spent. Congress accordingly passed a law creating a *board of ordnance and fortification* whose duty it was "to make all needful and proper purchases, experiments, and tests to ascertain, with a view to their utilization by the Government, the most effective guns, small-arms, cartridges, projectiles, fuses, explosives, torpedoes, armour-plates, and other implements and engines of war." The membership of this board comprises the lieutenant-general commanding the army (who is its president), one officer each from the corps of engineers and the ordnance department, two from the artillery, and one civilian. An officer of the army is detailed as recorder of the board.

By the Act of 2nd February 1901 *each regiment of cavalry* consists of 1 colonel, 1 lieutenant-colonel, 3 majors, 15 captains, 15 first lieutenants, and 15 second lieutenants; 2 veterinarians, 1 sergeant-major, 1 quartermaster-sergeant, 1 commissary-sergeant, 3 squadron sergeants-major, 2 colour-sergeants, 1 band, and 12 troops organized into 3 squadrons of 4 troops each. Each troop of cavalry consists of 1 captain, 1 first lieutenant, 1 second lieutenant, 1 first sergeant, 1 quartermaster-sergeant, 6 sergeants, 6 corporals, 2 cooks, 2 farriers and blacksmiths, 1 saddler, 1 wagoner, 2 trumpeters, and 43 privates. Each *regiment of infantry* consists of 1 colonel, 1 lieutenant-colonel, 3 majors, 15 captains, 15 first lieutenants, and 15 second lieutenants; 1 sergeant-major, 1 quartermaster-sergeant, 1 commissary-sergeant, 3 battalion sergeants-major, 2 colour-sergeants, 1 band, and 12 companies, organized into 3 battalions of 4 companies each. Each infantry company consists of 1 captain, 1 first lieutenant, 1 second lieutenant, 1 first sergeant, 1 quartermaster-sergeant, 4 sergeants, six corporals, 2 cooks, 2 musicians, 1 artificer, and 48 privates. The regimental organization of the artillery arm of the United States army is discontinued, and that arm is constituted and designated as the *artillery corps*. It comprises 2 branches, the coast artillery and the field artillery. The coast artillery is defined as that portion charged with the care and use of the fixed and movable elements of land and coast fortifications, including the submarine mine and torpedo defences; and the field artillery as that portion accompanying an army in the field, and including field and light artillery proper, horse artillery, siege artillery, mountain artillery, and also machine-gun batteries. All officers of artillery are on one list, in respect to promotion, according to seniority in their several grades, and are assigned to coast or to field artillery according to their special aptitude for the respective services. The artillery corps consists of a chief of artillery, selected and detailed by the President from the colonels of artillery, to serve on the staff of the general officer commanding the army, and his duties are prescribed by the Secretary of War; 14 colonels, 1 of whom shall be the chief of artillery; 13 lieutenant-colonels, 39 majors, 195 captains, 195 first lieutenants, 195 second lieutenants, 21 sergeants-major (senior grade), 27 sergeants-major (junior grade), 1 electrician sergeant to each coast artillery post having electrical appliances, 30 batteries of field artillery, 126 batteries of coast artillery, and 10 bands. The strength of batteries and companies is fixed by the secretary of war, but the aggregate number of enlisted men for the artillery shall not exceed 18,920. Captains and lieutenants of cavalry, artillery, and infantry, not required for duty with troops, batteries, or companies, are available for regimental staff or other details.

The above organization provides for an enlisted strength of about 58,000 men. In case of emergency the President is authorized to enlarge it, so that the maximum shall not exceed 100,000 men. This increase is to be effected by augmenting the number of men in a company, troop, or battery, without adding to the number of organizations or of officers.

The cavalry is armed with the Krag-Jorgensen carbine, cal. 30, the revolver, cal. 38, and the sabre. The thimble waist-belt of woven web carries 100 carbine and 12 revolver cartridges. The infantry and coast artillery have the Krag-Jorgensen rifle, cal. 30. The woven waist-belt carries 100 cartridges. Horse and mountain batteries may be organized, but there are none at present in service. With the exception of one siege battery of 5-inch guns and one of 7-inch howitzers, all the field batteries have the 3·2 B.L. rifle. When mountain guns are needed, they are issued to regular field batteries, or batteries are temporarily formed by details from other organizations. Each man has a revolver, non-commissioned officers and trumpeters having also a sabre.

Promotion in the line of the army is exclusively by seniority in the arm, a vacancy among the majors of cavalry, for instance, being filled by the senior captain of cavalry. Examination for promotion obtains up to the grade of major. An officer found physically disqualified from causes incidental to the service is retired with the grade to which his promotion would have entitled him. Should he fail in the educational examination,[1] he is suspended from promotion for a year, when he is again examined. Should he again fail, he is dropped from the rolls of the army. Retirement of all officers is compulsory at the age of 64 years. Officers have the right to retire on their own application after forty years' service, and may do so, on their own application, in the discretion of the President, after thirty years'. An officer may be retired at any period of his service for physical disability should a board of officers so recommend. Officers going on the retired list in any of the ways mentioned receive three-fourths of the full pay of their grade. In time of war retired officers may be employed on active duty, other than in command of troops, and they then receive full pay and allowances.

The army is recruited entirely by voluntary enlistment. Recruiting officers are maintained in the principal cities and towns. In ordinary circumstances each regiment furnishes one officer for a two years' tour of recruiting duty, but during active service in the field this duty is largely performed by convalescent officers. These officers report direct to the adjutant-general. The principal requirements for enlistment are that the applicant for first enlistment must be between the ages of 18 and 35; must be of good character; must be able to read and write the English language; must be a citizen of the United States or have legally declared his intention to become such; and must pass a rigid physical examination. The records for a number of years show that over 80 per cent. of applicants for enlistment are rejected. The term of enlistment is three years. The pay of a soldier ranges from that of a private (13 dollars a month) up through the various grades to that of a chief musician (60 dollars a month). The third year a dollar a month is added, the fourth year (should the soldier re-enlist) two dollars a month, the fifth year three dollars a month, and the sixth year five dollars a month. Thereafter a dollar a month is added for each five years' service. After thirty years' service the soldier is entitled to go on the retired list with three-fourths of pay and allowances. The soldier has a liberal allowance of clothing, and his food is furnished, so that his pay is almost all spending money. Retired officers and men form a part of the army and are paid by army paymasters. Pensions, in regard to which the country is very liberal (they call for about 140,000,000 dollars annually) are paid to persons no longer in the service, and the money is not disbursed by the War Department.

Officers.

The principal source from which officers are supplied to the army is the Military Academy at West Point. The President has thirty appointments of cadets at his disposal, which are generally given to sons of army and navy officers. Each senator and each representative and delegate in Congress has one. These appointments are not made annually, but as vacancies occur through graduation of cadets, or their discharge before graduation. The maximum number of cadets is 481. The commanding officer of the academy has the title of superintendent. He is detailed from the army, and has the temporary rank of colonel. The corps of cadets is organized as a battalion, and is commanded by an officer detailed from the army, having the title of commandant of cadets. He has the temporary rank of lieutenant-colonel. An officer of engineers and of ordnance are detailed as instructors of practical military engineering and of ordnance and gunnery respectively. The heads of the other departments of instruction have the title of professors. They are selected generally from officers of the army, and their positions are permanent. The officers above mentioned, and the professors, constitute the academic board. The military staff and assistant instructors are officers of the army. The course of instruction covers four years, and is very thorough. Theoretical instruction comprises mathematics, French, Spanish, English, drawing, physics, astronomy, chemistry, ordnance and gunnery, art of war, civil and military engineering, law (international, constitutional, and military), history, and drill regulations of all arms. Practical instruction comprises the service drills in infantry, cavalry, and artillery, surveying, reconnaissances, field engineering, construction of temporary bridges, simple astronomical observations, fencing, gymnastics, and swimming. Cadets are a part of the army, and rank between second lieutenants and the highest grade of non-commissioned officers. They receive from the Government a rate of pay sufficient to cover all necessary expenses at the academy. About 50 per cent. of those entering are able to complete the course. The graduating class each year numbers, on an average, about 60. A class, on graduating, is arranged in order according to merit, and its members are assigned as second lieutenants to corps and arm, according to the recommendation of the academic board. A few at the head of the class go into the corps of engineers; the next in order generally go into the artillery, and the rest of the class into the cavalry and infantry. The choice of graduates as to arm of service and regiments is consulted as far as practicable. Any enlisted man who has served honestly and faithfully not less than two years, who is between 21 and 30 years of age, unmarried, a citizen of the United States and of good moral character, may aspire to a commission. To obtain it he must pass an educational and physical examination before a board of five officers. This board must also inquire as to the character, capacity, and record of the candidate. Many well-educated young men, unable to obtain appointments to West Point, enlist in the army for the express purpose of obtaining a commission. Vacancies in the grade of second lieutenant remaining, after the graduates of the Military Academy and qualified enlisted men have been appointed, are filled from civil life. To be eligible for appointment a candidate must be a citizen of the United States, unmarried, between the ages of 21 and 27 years, and must be approved by an examining board of five officers as to habits, moral character, physical ability, education and general fitness for the service. In time of peace very few appointments from civil life are made, but in time of war there is a large number.

There are, in addition to the Engineer School already mentioned, four service schools for officers. These are: the Artillery School at Fort Monroe, Virginia; the Infantry and Cavalry School at Fort Leavenworth, Kansas; the Cavalry and Light Artillery School at Fort Riley, Kansas; the Army Medical School at Washington. The commandants, staffs, and instructors at these schools are officers specially selected. The garrison at Fort Monroe is composed of several companies of coast artillery. The lieutenants constitute the class. They are relieved and replaced by others on 1st September of each year. The course of instruction comprises the following subjects: artillery, ballistics, engineering, steam and mechanics, electricity and mines, chemistry and explosives, military science, practical military exercises, photography, telegraphy, and cordage (the use of ropes, the making of various kinds of knots and lashings, rigging shears, &c., for the handling of heavy guns). July and August of each year are ordinarily devoted to artillery target practice. The course at the Infantry and Cavalry School is for two years. The class of student officers is made up of one lieutenant from each regiment of infantry and cavalry, and such others as may be detailed. They are assigned to the organizations comprising the garrison, normally a regiment of infantry, a squadron (four troops) of cavalry, and a battery of field artillery. The departments of instruction are: military art, engineering, law, infantry, cavalry, military hygiene. Much attention is paid to practical work in the minor operations of war, the troops of the garrison being utilized in connection therewith. At the close of the final examinations of each class at Fort Monroe and Fort Leavenworth, those officers most distinguished for proficiency are reported to the adjutant-general of the army. Two from each class of the Artillery School, and not more than five (the number to be determined by the lieutenant-general commanding the army) from each class at the Infantry and Cavalry School, are thereafter, so long as they remain in the service, noted in the annual army register as "honour graduates." The work of the Cavalry and Light Artillery School at Fort Riley is mainly practical, and is carried on by the regular garrison, which usually, in time of peace, consists of two squadrons of cavalry and three field batteries. The Government reservation at Fort Riley comprises about forty square miles of varied terrain, so that opportunities are afforded, and taken advantage of, for all kinds of field operations. The Army Medical School is established at Washington. The faculty consists of four or more professors selected from the senior officers of the medical department. The course of instruction covers a period of five months, beginning annually in November. The student officers are recently-appointed medical officers, and such other medical officers, available for detail, as may desire to take the course. Instruction is by lecture and practical work, special attention being given to the following subjects: duties of medical officers in peace and war; hospital administration; military medicine, surgery and hygiene; microscopy and bacteriology; hospital corps drill and first aid to the wounded.

---

[1] That is, an examination in English grammar, mathematics, geography, history, constitutional and international law.

The territory controlled by the United States, at home and abroad, is divided into territorial departments. These are established and their commanders assigned by direction of the President. In time of peace, army corps, divisions, or brigades are not formed except for purposes of instruction. The commander of a military department controls all the military forces of the Government within its limits, whether of the line or staff, which are not specially excepted. The exceptions include the Military Academy, the Artillery School, the schools at Forts Leavenworth and Riley in matters pertaining to the courses of instruction, the engineer establishment at Willets Point, arsenals, general depots of supply, general service recruiting stations, permanent fortifications in process of construction, and officers employed on special duty under the Secretary of War. But when an emergency demands it, all military men and material within the limits of their jurisdiction come under their control. A department commander is charged with the administration of all the military affairs of his department, and the execution of all orders from higher authority. He reports to the Commanding General of the Army all matters relating to the general welfare of his command, including such change of station of troops as he may deem desirable, but must obtain approval of the Commanding General of the Army before ordering the movement. If it be necessary to move troops to meet emergencies, such movements, and all the circumstances connected with them, must be reported at the earliest possible moment. The personal staff of a department commander consists of the authorized aids. The department staff is limited to the officers detailed by the Secretary of War from appropriate staff departments or corps, or of officers of the line detailed by the same authority to act in their stead, and their official designations are as follows: adjutant-general, chief quartermaster, chief commissary, chief surgeon, chief paymaster, judge advocate, and artillery inspector; also, when necessary, an engineer officer, an ordnance officer, and a signal officer, each detailed from his corps.

There are in the United States proper, including Alaska, about one hundred military posts. The garrisons of a majority of them, even when large forces are not needed out of the country, are necessarily small. The various staff positions at a post, such as adjutant, quartermaster, commissary, signal officer, and ordnance officer, are usually filled by lieutenants of the garrison temporarily detailed. At a post having the headquarters of a regiment, the first three positions above mentioned are filled by the regimental adjutant, quartermaster, and commissary respectively. The regimental adjutant, quartermaster, and commissary are selected from the captains, and the tour is limited to four years. As the great majority of officers of the line have, before obtaining their captaincies, filled one or more of the various staff positions, in addition to having taken the course at a service school, there is always available a large number of officers thoroughly qualified to fill any staff position.

The Act of 2nd March 1899 authorized the President to raise a volunteer force of 35,000 men for service in the Philippines, to continue in service not later than 30th June 1901, on which date the strength of the regular army, with the exception of the artillery, was to be reduced to the numbers in service prior to the outbreak of the war with Spain. On 5th July 1899 the President ordered the organization of ten regiments of volunteer infantry; on 18th July 1899, of two regiments of volunteer infantry and a regiment of volunteer cavalry (the three last-named regiments to be organized and recruited in the Philippine Islands); on 17th August 1899, of ten additional regiments of volunteer infantry; and on 9th September 1899, of two additional regiments of volunteer infantry (the enlisted men and company officers of the two last regiments to be coloured). Each regiment was organized at an army post. The men were recruited by regular army recruiting officers throughout the country, and were sent at once to the nearest regimental rendezvous. The time required, under each order, was about six weeks. All the colonels, nearly all the lieutenant-colonels and majors, and a few of the captains, were selected officers of the regular army. Most of the other officers and a large percentage of the men, had served, in the regulars or volunteers, in the war with Spain. The training of the men began at once on arrival at rendezvous, special attention being given to instruction in duties of guards and outposts, to fighting in extended order, and to target practice. The physical examinations were rigid, and the character of the accepted personnel was excellent. The result was the best volunteer force ever raised in the United States. The first regiment sailed for Manila, 8th September 1899, and the last, 21st December. They were at once ready to take the field on arrival, and did most excellent service. One instance is the remarkable and energetic pursuit of the insurgents by volunteer troops, through the mountainous, heavily-wooded, entirely unknown country of northern Luzon, where transportation of supplies was at all times difficult and in many cases impracticable.

The Act of 2nd February 1901 repealed so much of the Act of 2nd March 1899 as provided for a reduction of force, 30th June 1901, and put the regular army on a permanent basis. It authorized the raising of 12,000 (provided the maximum of 100,000 for the entire army was not exceeded) Philippine native troops, organized into companies and battalions; the majors and captains being selected from the next lower grades in the line of the army. It also provided for a three-battalion native Porto Rican regiment, the field officers and captains to be selected as for the Philippine native troops.

The United States has never had a satisfactory system of increasing its armed strength for war. The subject has received a great deal of attention, and much legislation has been proposed, but the form of government makes the question very difficult of solution. The militia, numbering about 115,000 officers and men, is distributed through the various States, constitutes State troops, and is independent of the general government. Disorders within the limits of a State are to be dealt with by the State authorities, and the Constitution expressly prohibits the use of United States troops in such cases, except upon the formal application of the State authorities. The several States are very jealous of their prerogatives and never call for federal troops except as a last resort. The method adopted for raising the twenty-five regiments of volunteers for Philippine service proved very satisfactory, but might not be feasible for the sudden creation of a large army. It would require much time, and there would not be a large enough number of regular officers available. The practice both in the Civil War and in the war with Spain was for the President to decide upon the number of men required, and then call upon Governors of States to furnish each their quota, according to population. Regiments were then organized in the several States, either by filling up organizations of the militia already existing, or by creating entirely new ones. The officers were appointed by the respective Governors. The troops thus organized did not come under federal control until formally mustered into the service of the United States; and this means of rapidly raising a large army has been found by experience to be inefficient and expensive. (W. A. S.)

GERMANY.

The liability to service in the German army is universal, and lasts from the 17th to the 45th year. Liability to active service begins on the 1st January of the year in which the man completes his 20th year, and is divided into service in the standing army, its reserve, and the landwehr of the 1st and 2nd bans. Liability to serve in the standing army lasts for three years from the date of joining (usually in October), for men posted to the cavalry and horse artillery, and for two years for the other arms; but these latter may also be held to serve three years. Thereafter, men belong to the reserve for four years, and are passed to the 1st ban of the landwehr in the spring following the date on which they complete seven years' service. Service in the 1st ban lasts five years, and in the 2nd is prolonged to the 31st March of the year in which the man completes his 39th year, *i.e.*, for the most part, six years. Men who serve three years with the colours only pass three years in the 1st ban of the landwehr. During their period of reserve service, men are liable to two trainings of eight weeks each, though the vast bulk only do one of fourteen days, and during their service in the 1st ban of the landwehr to two trainings of eight to fourteen days, the bulk being, however, only called out once for fourteen days. The men of the 2nd ban of the landwehr are liable neither to training nor to periodical control musters. To the landsturm belong all males liable to service, and not otherwise belonging to the army or navy, from their seventeenth to their forty-fifth year; its 1st ban comprising those of thirty-nine years and under, its 2nd the others. Its men are not trained in peace.

Volunteers are taken, from among men who have completed their seventeenth year, to serve for three years in the cavalry and horse artillery, and for two years in the other arms. These men may choose their own regiments; so that volunteering is preferred by men who either desire to make the army a profession, or, for private reasons, wish to complete their active service earlier, or have a fancy for a particular regiment. A special category is formed by the one-year volunteers, who must pass a high educational test or have gone through certain classes in the schools. These receive no pay, clothe and equip themselves, and in the mounted branches find their own horses, in consideration of which they only serve one year actively. They are supernumerary to the establishment, and their number is unlimited. Both categories of volunteers pass into the reserve, &c., with men of their own age recruited compulsorily.

Recruiting is managed by committees of officers and civil officials in each recruiting (landwehr) district. These draw up lists, decide on exemptions allowed by law, and conduct the medical examinations. All men passed as liable and fit draw lots for numbers, and the lowest numbers are taken up to the contingent required. No substitution is allowed.

Non-commissioned officers (corporals and above) are obtained from two classes—(*a*) from the two- or three-year volunteers mentioned above, or (*b*) from the non-commissioned officers' schools, which youths of seventeen to twenty years of age voluntarily join. Their course there lasts three (in exceptional cases, two) years, and they are bound to serve four years in the army after leaving the school. Non-commissioned officers are encouraged to remain in the army by a promise of employment in the gendarmerie after nine, or in the civil service after twelve years; and on leaving the army they receive a gratuity which varies from 50s., after five, to £50 after twelve years' service. Pensions are given to invalids.

Officers are obtained from two sources—(*a*) cadets, and (*b*) two- or three-year volunteers. Cadets join a provincial cadet-house between ten and fifteen years of age, and afterwards pass two and a half years in the Central Institution, near Berlin. At about eighteen years of age, they are appointed ensigns (*Fähnrich*, an intermediate rank between officer and non-commissioned officer) direct. Those volunteers who desire to become officers must be approved of by their commanding officer, and pass an examination or produce equivalent school certificates. They are private soldiers, but are known as aspirants to commissions (*Fahnenjunker*); they may live at the officers' mess, and may wear when off duty uniforms of finer cloth. After five months' actual service, and being passed professionally, they may be promoted ensigns. All ensigns must pass through a "war school," at which the course (military subjects, both theoretical and practical instruction) lasts nine months; after which they pass their "officers' examination," and are nominated lieutenants as vacancies arise. They must, however, be first balloted for and accepted by the officers of the regiment they are to join.

Officers of the reserve come, for the most part, from former one-year volunteers, who, after their one year's service, do two trainings of eight weeks each, and pass an examination. The one-year volunteers who do not become reserve officers become non-commissioned officers of the reserve.

There are four separate armies—those of Prussia and of the minor states, Bavaria, Saxony, and Würtemberg—each administered separately by its own War Ministry, but all bound to conform as regards organization, formation, training, pay, command, mobilization, and (to a great extent) clothing, to fixed regulations. The minor states have concluded military conventions with Prussia, and their contingents are administered by its War Ministry. By the law of 25th March 1899 the army was to be raised from the 1st October 1899 onwards to a strength of 495,500 lance-corporals and privates, which figure was to be attained in 1903, and at this strength it was to remain till 31st March 1904. It is divided into the following units, the figures in brackets showing those actually existing after the new formations of 1st October 1899 were completed:—Infantry, 625 (624) battalions; cavalry, including mounted rifles, 482 (472) squadrons; field artillery, 574 (541) batteries; foot artillery, 38 (37) battalions; pioneers, 26 (24) battalions; communications troops, 11 (10) battalions; train, 23 (22) battalions. The *infantry* consists of 175 regiments of 3 battalions, 41 regiments of 2 battalions, and 18 rifle battalions. Each battalion has 4 companies. A number of those on the frontiers have an establishment of 640 non-commissioned officers and men, the remainder have one of 570 only. The infantry is armed with magazine rifles of 8 millimetres' calibre, loaded by packets of 5 cartridges at a time, and bayonets. In marching order, each man carries 120 rounds of ammunition and his share of a portable tent equipment. The *cavalry* consists of 93 regiments of 5 squadrons each, of which 14 are heavy, 25 medium (lancers), and 54 light (dragoons and hussars). A regiment has 681 non-commissioned officers and men, and 667 horses, but those on the frontiers are slightly stronger. The armament of all cavalry consists of steel-shafted lances (for both ranks), carbines of the same construction as the infantry rifle, and swords. The *mounted rifles* consisted in 1900 of 7 squadrons, and 10 more were to be raised. Each has 133 non-commissioned officers and men, and 132 horses. They are armed with swords and revolvers, and are used as orderlies, scouts, &c., and attached to various staffs. The *field artillery*, consisting in 1900 of 85 regiments, was to attain its full strength of 94 regiments in 1901, each regiment having 6 batteries in 2 brigade divisions of 3 batteries each. In 6 regiments (one of these brigade divisions), and in 2 other regiments, one of the 6 batteries is of horse artillery. Eleven of the regiments have each an extra brigade division of 2 horse artillery batteries, which, on mobilization, would join the cavalry divisions. In each army corps (see below) one brigade division of one of the regiments consists of 3 field howitzer batteries. About one-third of the field batteries are on a higher establishment of 115 non-commissioned officers and men, 60 horses, and 6 guns (there are 12 batteries on a still higher establishment); the remainder having 102 men, 44 horses, and 4 guns horsed. The horse batteries for the cavalry divisions have 121 non-commissioned officers and men, 120 horses, 6 guns, and 2 waggons horsed; the others, 92 men, 76 horses, and 4 guns. The guns are of 1896 pattern, nickel-steel quick-loaders of 7·7 cm. calibre, and the howitzers of 1898 pattern of 10·5 cm. calibre. Both fire shrapnel shell and shell filled with high explosives. A battalion of *foot artillery* has 4 companies, with 595 non-commissioned officers and men. Two (in 2 cases 3) battalions form a regiment. This arm is trained for siege and inland fortress duties (except 3 battalions as coast artillery), and also mans the *heavy* position and howitzer batteries of the field army. The *pioneers* are organized in single battalions of 4 companies, with 611 non-commissioned officers and men, and are armed as infantry. They are trained in field and siege works and bridging. The *communications troops* consist of 3 railway regiments of 2 battalions each, and 1 independent battalion, 3 telegraph battalions, and a balloon company (to be expanded to a battalion of 2 companies). The *train battalions* correspond to the transport branch of the British Army Service Corps, and have each 3 companies, with 299 non-commissioned officers and men, and 190 horses. To 8 of them are attached sections of 59 men and 57 heavy draught horses for batteries of position.

The army is divided into 23 *army corps*. Twenty-two of these are assigned to certain territorial districts for recruiting, and the Prussian Guard Corps is recruited from the whole kingdom. Of these 22 (21) corps, 16 are furnished by Prussia, &c., 3 (2) by Bavaria, 2 by Saxony, and 1 by Würtemberg. There are exceptions in many cases, but the usual composition of an army corps, when the artillery had reached its full strength, was to be: 2 divisions each of 2 (in 9 divisions, 3) brigades of infantry, each of 2 regiments, 1 brigade of cavalry of 2 regiments, and 1 brigade of field artillery of 2 regiments, besides which the corps would have 1 squadron of mounted rifles, 1 battalion of rifles, 1 foot artillery regiment, 1 pioneer battalion, and 1 train battalion. The 1st and 14th corps have each 3 divisions. In the various War Ministries mentioned above, the administration of the armies is conducted. Prussia and Bavaria have in addition a "Great General Staff," in which the preparation of the army for war and its employment in the field are studied. There is, further, in each State a "Military Cabinet,' in which all questions of the promotion and appointment of officers are dealt with. The heads of these three departments are independent of each other, and are directly subordinate to the sovereign. Great independence is allowed to generals commanding army corps, who are directly responsible to the sovereign for the training and preparation for war of their troops.

The standing army would take the field as it stands in peace, except that the bulk of the cavalry would be formed into independent cavalry divisions, each of 6 regiments and 2 batteries of horse artillery, and that certain units of its artillery and engineers serve as *cadres* for 2nd line formations. An infantry battalion on the war footing has 26 officers and officials, 1031 other ranks, 46 horses, 15 carriages; a cavalry regiment of 4 squadrons (one of the squadrons being left behind as a depot), 31 officers, &c., 665 men, 741 horses, and 17 carriages; a horse battery, 5 officers, 166 men, 236 horses, 6 guns, 9 ammunition waggons, and 5 other carriages; and a field battery, 5 officers, 171 men, 150 horses, and carriages as in a horse battery. A normal army corps would have 25 to 29 battalions, 4 or 5 squadrons, 21 batteries, 3 pioneer companies, &c., or a total fighting strength of 25,000 to 29,000 infantry, 600 to 750 cavalry, 126 guns, and 750 pioneers, with a ration strength of 37,000 to 41,000 men and 12,000 horses. A cavalry division with 24 squadrons and 2 batteries would have a ration strength of about 4800 men and 5100 horses. It is not known to what extent reserve and landwehr troops would be formed, but it is generally assumed that a division of all arms of each category, 12,000 to 20,000 strong, would be formed in each army corps, which would give a 2nd line army equal in strength to the mobilized standing army, about half of which might easily be employed in 1st line. Roughly speaking, without calling on the landsturm, Germany could put 2,000,000 men in the field, and keep another 1,000,000 for home garrisons and depots.

The total budgetary strength of the German army for 1899 was :—23,730 officers, 79,873 non-commissioned officers, 491,826 men, 2155 surgeons, 2805 paymasters, veterinary surgeons, armourers, and saddlers, and 101,065 troop horses. The above figures are exclusive of the colonial troops, which are insignificant in number, there being in South-west Africa a force of about 750 Germans, in East Africa about 130 Germans and 1600 natives, in Togoland 3 Germans and 150 natives, and in Cameroon 15 Germans and 300 natives. Kiaochow is held by marines from the Imperial Navy. (J. M. Gr.)

FRANCE.

Every Frenchman becomes liable to military service at the age of 20. This liability dates from the conscription law passed at Jourdan's instance on 5th September 1798. But the principle of universal service was soon impaired by the admission of substitutes, authorized by the decree of 7th March 1800, and at length abolished by the recruiting law of 27th July 1872. This was replaced on 15th July 1889 by a new law, which extended the total period of military service from 20 to 25 years, but reduced the term of service with the colours from 5 years to 3. This term was to be followed by 7 years in the reserve of the active army, 6 years in the territorial army, and 9 years in the reserve of the territorial army. Exemptions for family or educational reasons were withdrawn, and those who had hitherto been allowed the benefit of them were required to serve for one year with the colours. Those who are physically unfit to bear arms may be employed in the auxiliary services in time of war. To adjust the strength of the standing army to the annual budget, the minister of war is given power to release three-years' men when they have completed one year's service. The average annual contingent is about 200,000 able-bodied men, of whom about one-third are released at the end of the first year. There are also about 20,000 volunteers who serve for one year, and may prolong their service to five years. The law of 1889 was modified on 19th July 1892, the term of service in the reserve of the standing army being prolonged to 10 years, and that in the reserve of the territorial army reduced to 6 years. In the infantry and cavalry more than half the subaltern officers are from the ranks, the rest being from the military schools. In the artillery and engineers about three-fourths come from the schools. Promotion is partly by seniority, partly by selection. The latter method is applied to one-third of the promotions to the rank of captain, to one-half of those to the next grade (battalion, or squadron, commander), and to all above that rank.

The organization of the army is based upon the law of 24th July 1873, which fixed the territorial system, supplemented by the cadre law of 13th March 1875, which defined the number of units. But there have been several changes since. At present the units of the standing army are as follows:—

Infantry.—173 regiments, viz., 163 of the line, 4 of Zouaves, 4 of Algerian rifles, and 2 foreign. The regiments are nominally of 4 battalions, but some fourth battalions are wanting. The Zouave and foreign regiments have 5 battalions, and 3 of the Algerian rifles have 6. Each battalion consists of 4 companies, which, in line regiments, have a peace strength of 127 men, in the Zouave and foreign regiments of 151, and in the Algerian rifles of 164. There are 30 battalions of *chasseurs à pied*, each consisting of 6 companies. Twelve are mountain battalions and have 150 men per company; the others have 133 men. There are 5 battalions of African light infantry, each having 6 companies of 250 men. There are 4 disciplinary companies of variable strength.

Cavalry.—Eighty-nine regiments, viz., 13 of cuirassiers, 31 of dragoons, and 45 of light cavalry (chasseurs, hussars, chasseurs d'Afrique and spahis). The regiments generally have 5 squadrons of 150 men; the 4 spahi regiments have 22 squadrons in all, of 178 men. There are also 8 remount companies.

Artillery.—Eighteen battalions of foot (or fortress) artillery, comprising 105 batteries, with a peace strength of 129 men each. Twenty brigades (40 regiments) of field and horse artillery, comprising 442 field and 52 horse batteries of 103 men, and 14 mountain batteries of 156 men. When serving in Algeria the batteries are of higher strength.

Engineers.—Seven regiments, including 1 railway regiment. Two are of 4 battalions, the others of 3 battalions. There are 4 companies to each battalion, the railway companies having a strength of 160, and the others of 108 men. Each regiment has also a company of "train." The engineer staff numbers 460 officers and 868 subordinates.

The infantry are armed with the "Lebel rifle" of 1886, 8 mm. (0·315 in.) in calibre. It is sighted to 2000 metres, and has a magazine for 8 cartridges in the stock. The batteries—field, horse, and mountain—are of 6 guns each. The field artillery gun is of 90 mm. (3·54 in) calibre; the horse artillery gun is of 80 mm. (3·15 in.) calibre. A quick-firing gun of 75 mm. (3 in.) is being rapidly introduced. It is of nickel steel, and weighs with its carriage about 19 cwt., rather more than the horse artillery gun. It is said to have a range of 7000 metres, and to be capable of firing 20 rounds a minute. The weight of its shell is 15½ ℔. A field howitzer of 120 mm. (4·7 in.) calibre has also been adopted. It weighs, with its carriage, 29 cwt., and has a range of 6000 metres. Besides shrapnel, it fires long shells weighing 45 ℔, with a bursting charge of 13 ℔ of melinite.

Two regiments of infantry or cavalry form a brigade; 2 infantry brigades, with 6 field batteries, 1 company of engineers, &c., form an infantry division; and, as a rule, 2 infantry divisions, with a battalion of chasseurs, a brigade of cavalry, 8 batteries of field and horse artillery, &c., form an army corps. The foot artillery is allotted to those army corps which have fortresses within their regions. France is divided into 19 army corps regions, and Algeria forms an additional one. The principal elements of the field army corps, with the staff and the cadres of the territorial army, are, as a rule, quartered in the region assigned to it, though its recruits are not necessarily drawn from its region. Outside the army corps there are 7 independent cavalry divisions of 3 brigades and 3 horse batteries each. The Algerian army corps (numbered xix) has 3 divisions. It consists mainly of Zouave and African regiments, but draws its artillery and engineers from regiments in France. There is also a separate division in Tunis. The effective strength of the standing army in 1898 was 544,000 officers and men. On mobilization for war the strength of the companies of infantry of the line and chasseurs is raised to 250 men, of engineer companies to 262 men, of field batteries to 180, and horse batteries to 190 men. There is little change in the squadrons of cavalry. On a war footing a cavalry brigade numbers about 1200 men, an infantry brigade 6000, an army corps nearly 40,000 men. As a fighting force it may be reckoned at 25,000 infantry, 1200 cavalry, and 120 guns. Armies (the commanders of which are designated beforehand) would be formed by groups of three or more corps, and the cavalry divisions would be attached to them. The territorial army would be used chiefly for garrisons and on lines of communication. The strength of its units when mobilized is generally the same as that of similar units of the active army, but it is not at present organized in brigades. Each army corps region would furnish 8 regiments of infantry, 8 squadrons of cavalry, 1 regiment of artillery, and 1 battalion of engineers. The total war strength of the active army and its reserve would be nearly 2½ millions, and the territorial army with its reserve would raise this total to about 4½ millions of trained men when the present laws have had their full effect (viz., in 1915). This is more than 11 per cent of the population. (R. M. L.)

ITALY.

The Italian military organization is governed by laws enacted in 1883, 1884, 1887, and 1888. The armed strength consists of (1) the active army, (2) the mobile militia, (3) the territorial militia. The annual contingent for service with the colours is determined by Parliament, and selected by lot from the men who reach the age of 20 in each year; the rest pass at once into the reserve; men exempted from service in the active army, but fit to bear arms, pass into the territorial militia. The liability to service lasts from the age of 20 to 39, and the 19 years may be spent as follows:—

ACTIVE ARMY.		MILITIA.	
With Colours.	Reserve.	Mobile.	Territorial.
Years.	Years.	Years.	Years.
3	5	4	7
...	6	4	7
...	...	...	19

Cavalry.—There are 24 regiments, each of 6 squadrons, and a depot. Twelve regiments are told off, one to each army corps; the rest would be formed into 3 cavalry divisions of 2 brigades of 2 regiments. All regiments have a territorial title as well as a number. The war strength is 43 officers and 845 men, of whom 740 are mounted.

Artillery.—There is 1 horse artillery regiment, consisting of 6 batteries of 6 guns. The battery at war strength contains 4 officers, 150 N.C.O.'s and men, and 166 horses. The regiment would form 6 brigades of 2 batteries to act with the 3 cavalry divisions. The field artillery comprises 24 regiments—12 divisional and 12 corps artillery. Each regiment contains 2 brigades of 4 batteries and a depot battery. A divisional regiment contains 47 officers, 904 men, and 428 horses; a corps regiment has 53 officers, 997 men, and 458 horses. The light battery is armed with a gun firing a 9¼ lb. shell. The total weight of the gun and limber is 30½ cwt. The heavy batteries are equipped with guns firing a 14·9 shell, and the weight behind the team is about 41½ cwt. A heavy brigade is attached to each infantry division, and a mixed brigade of 2 heavy and 2 light batteries is allotted to each army corps. The mountain artillery is organized in 1 regiment of 9 batteries of 6 guns and a depot. On a war footing each battery has 4 officers, 150 men, and 63 pack animals. The garrison artillery forms 3 regiments, each of 12 companies, and 1 depot, and 2 regiments of 16 companies and 1 depot. A company contains 3 officers and 100 men. The garrison artillery supplies the *personnel* for siege parks, for fortresses, or fortified positions, and for coast batteries.

Infantry.—The infantry of the line forms 2 regiments of grenadiers and 94 other regiments, organized in 48 brigades bearing local titles, and 24 divisions. A regiment has 3 battalions of 4 companies and a depot. The strength of a regiment and a battalion is:—

		Off.	N.C.O.'s and Men.
Regiment	Peace	61	1299
	War	76	2511
Battalion	Peace	15	400
	War	24	918

In addition to line infantry, there are 12 regiments of bersaglieri, which are not brigaded, and 7 regiments of Alpini, specially trained for mountain warfare. The regular infantry is armed with the Mannlicher magazine rifle, calibre 0·257 inch, weighing with bayonet 9 ℔ 2 oz.

Engineers.—These form 2 regiments, each of 16 sapper or field companies; 1 regiment of 7 sapper companies, 6 telegraph companies, 3 transport companies, and 1 specialist company; 1 regiment of 8 pontoon companies, 2 special lagoon companies for service at Venice, 4 railway companies, and 3 transport companies. Each of the 4 regiments has a depot. The sapper or field companies furnish 1 company and 1 pontoon section to each division in the field, 1 engineer park to each army corps, 1 brigade of 3 companies to each field army. They also supply detachments for sieges or for work in fortresses. The telegraph companies furnish a telegraph park to each army corps and to each army in the field. The pontoon companies furnish to an army one or more bridging trains, each carrying about 200 yards of bridge.

Higher Organization.—An infantry division is composed of 2 brigades of infantry of 12 battalions, 1 brigade of artillery of 4 battalions of 6 guns, 1 company of engineers, 1 pontoon section, 1 ammunition column. It numbers at war strength 276 officers and 12,705 N.C.O.'s and men. A cavalry division comprises 2 brigades of 2 companies, and 2 horse artillery batteries numbering 213 officers and 3820 N.C.O.'s and men, together with an ammunition column and administration units. An army corps contains 2 divisions, with corps troops consisting of 1 regiment (3 battalions) of bersaglieri, 1 cavalry regiment of 6 squadrons, 2 artillery brigades (48 guns), the whole numbering 943 officers and 30,387 N.C.O.'s and men. There are also 1 corps ammunition column, 1 engineer park, 1 telegraph park, and administration units. The active army can supply 12 army corps.

Mobile Militia.—The mobile militia is organized in 144 infantry battalions of 4 companies, 18 battalions of bersaglieri, and 22 companies of Alpini. In addition there are 12 brigades of field artillery, each of 4 batteries, 34 companies of garrison artillery, 9 of mountain artillery, 30 companies of engineers; 4 field batteries and 2 companies of garrison artillery for Sicily; together with 9 battalions of line infantry, 1 battalion of bersaglieri, 1 squadron of cavalry, 2 batteries of field, and 1 company of garrison artillery for Sardinia.

Territorial militia is organized in 320 battalions of infantry, 75 companies of Alpini, 100 companies of garrison artillery, and 30 companies of engineers.

Colonial Troops.—A special force exists for the garrisoning of Eritrea composed of volunteers from the active army or reserve and of native troops.

The armed strength of Italy numbers about:—

	Officers.	N.C.O.'s and Men.
Active army and reserve .	19,450	805,000
Mobile militia . . .	3,600	295,500
Territorial militia . .	5,200	1,617,000
Total . .	28,250	2,717,500

(G. S. C.)

Austria-Hungary.

The military forces of Austria-Hungary consist of (1) the active army with its reserves, (2) the landwehr, (3) the landsturm. The active army is superintended by a single war ministry for the whole monarchy; but the landwehr and landsturm are under two separate ministries of national defence,—one for the troops of Hungary, Croatia, and Slavonia (the "Honved" troops), the other for the remaining states. Liability to military service was made universal in 1868. The law at present regulating it was passed in 1889. Except in "the occupied provinces," Bosnia and Herzegovina, which have special treatment in several respects, substitutes are not allowed. The liability begins at the age of 20, and the term of service is 12 years; but the nature of the service varies. Out of 180,000 able-bodied men annually available, over 100,000 are taken for the army, and after 3 years in its ranks, spend 7 years in the reserve and 2 years in the landwehr. About 23,000 serve their whole term in the landwehr. The remainder go to the ersatz (depot) reserve of the army or the landwehr as supernumeraries. The destination of the recruits is determined partly by lot, partly by their claims to consideration. Young men of good education are admitted as "one-year volunteers" at their own cost, or sometimes at the cost of the state. All men between the ages of 18 and 42 are further bound to serve in the landsturm, or general levy, if not otherwise enrolled; but the landsturm is not called out during peace, and in war only when the landwehr and ersatz-reserves are insufficient. Young men who are found unfit for service have to pay a military tax, according to their means, for the benefit of disabled soldiers, or of the widows and orphans of soldiers. The officers of the standing army are drawn from the military schools. Promotion is mainly by seniority, subject to tests of qualification, but selection is not excluded. The reserves are officered by retired officers and one-year volunteers. The units of the standing army (omitting depot cadres, &c.) are as follows:—

Infantry.—102 regiments of the line, 4 regiments of Tyrolese rifles, 4 Bosnian-Herzegovinian regiments, all of 4 battalions; also 26 independent rifle battalions: making a total of 466 battalions. There are four companies to each battalion, and their normal peace strength is 4 officers and 93 men.

Cavalry.—Forty-two regiments, viz., 15 dragoon, 16 hussar, and 11 uhlan. Each regiment has 6 squadrons and a pioneer section. The peace strength of a squadron is 5 officers and 166 men. The dragoons are recruited from the Austrian provinces, the hussars from Hungary, the uhlans mainly from Galicia. They are all armed alike with sabres and repeating carbines.

Artillery.—Fourteen brigades of field artillery, each consisting of 1 corps regiment and 3 divisional regiments. In each regiment there are 4 field batteries with a peace strength of 4 officers, 101 men, and 4 guns (to be raised to 8 guns in time of war). Attached to regiments of the corps artillery there are 8 divisions of horse artillery, making 16 horse batteries of 5 officers and 122 men each, and 11 batteries of mountain artillery of 2 officers and 60 men each. There are also 3 additional mountain batteries which form a separate division. Of fortress artillery there are 6 regiments and 3 independent battalions, making 18 battalions in all. In each battalion there are 4 field companies of 4 officers and 98 men.

Engineers, &c.—Fifteen pioneer battalions, each having 5 companies of 5 officers and 107 men. The 5th company is expanded into 3 fortress companies in war. The train includes bridge-equipment. There is a railway and telegraph regiment of 3 battalions, each having 4 companies of 50 officers and 118 men. The engineer staff comprises 146 officers.

The general staff of the army numbers 481 officers, of whom 276 belong to the staff corps, and the rest are attached. There are 29 infantry regiments (to be increased to 32) of Austrian landwehr, and 28 of Hungarian, making 195 battalions in all. Each battalion has 4 companies of about 55 men. The landwehr cavalry consists of 6 regiments of uhlans and 10 regiments of Hungarian hussars, of 6 squadrons each, and there are also 3 squadrons of Tyrolese and Dalmatian mounted infantry. The peace strength of the squadrons is from 43 to 65 men. There are no landwehr artillery or engineers. The infantry are armed with the Mannlicher magazine rifle of 8 mm. (0·315 inch) calibre, the latest pattern being of 1895. It is sighted to 3000 paces. The magazine holds 5 cartridges which are inserted simultaneously in a clip. The field and horse batteries are armed with steel-bronze guns of 9 cm. (3·42 inch) calibre, the field gun weighing 9½ cwt., and that of the horse artillery about 8 cwt. The pattern is of 1875, and no provision has yet been made for substituting quick-firing guns; but something has been done to check recoil and make the present guns more effective.

The higher units of the army are of variable strength. An infantry brigade consists of 6 to 9 battalions; a cavalry brigade of 2 or 3 regiments. Two brigades form a division. An infantry division comprises also 3 or 4 squadrons of cavalry, and a regiment (4 batteries) of field artillery. A cavalry division has 2 batteries of horse artillery and one or two battalions of rifles. A corps is ordinarily made up of 2 infantry divisions, a cavalry brigade, a regiment of corps artillery, and technical troops. The territory of Austria-Hungary (including Bosnia and Herzegovina) is divided into 15 corps districts and 1 divisional district (Zara in Dalmatia). There are 5 cavalry divisions, of which 2 are attached to the 11th corps (in East Galicia) and the other 3 to the 1st, 2nd, and 10th corps. The total peace strength of the regular army is about 283,000 men, and of the landwehr about 49,000, making 350,000 in all, officers included. The war strength of the various units is not published now, but the field troops available on mobilization would probably amount to 800,000 men, the landwehr to 320,000, the ersatz-reserves of army and landwehr to 480,000. It is reckoned that another million of trained men could be found in the landsturm. (E. M. L.)

Russia.

Since the war of 1877-78 many changes have been introduced into the Russian army, which was not previously organized in higher units than the division.

Under the law of Jan. 13, 1874, modified by that of June 14, 1888, and Jan. 19, 1893, liability to service extends from the beginning of the 21st to the end of the 43rd year of age. The first 18 years are passed in the standing army, the rest in the militia. Service with the colours lasts for 5 (in practice 4) years, the remaining term being spent in the reserve, which entails two trainings of six weeks each for the entire period. The army mobilized for war is composed of (1) field troops, (2) reserve troops, (3) depot troops, (4) fortress troops, (5) local troops, (6) militia.

(1) The field troops are composed of the standing army made up to war strength by calling out the reserves. (2) The reserve troops are formed by the expansion of reserve cadres maintained in peace. (3) Depot troops are formed upon cadres detached at the outbreak of war from the standing army. Their function is to keep the field units up to strength. (4 and 5) Fortress and local troops are brought up to war strength in the same way as reserve troops, but are intended to be employed only on garrison duties. (6) The militia comprises all men physically fit for military purposes between the ages of 21 and 43 inclusive, and is divided into 2 bans. The 1st ban contains the men who have served with the colours, and those who have not been included in the annual contingents, but are wholly fit for active service. It may be used to complete the field army, or to form militia units for home defence. The 2nd ban includes men exempted on special grounds from service with the colours, and those regarded as not wholly fit for operations in the field. Military service in Finland was regulated by the law of Jan. 13, 1881, which prescribed 3 years with the colours and 2 with the reserve, the rest of the military period up to the end of the 43rd year of age being passed in the militia. The conditions have, however, been assimilated to those of the empire. Cossacks serve under special regulations for 20 years, beginning with the completion of the 18th year of age. The first 4 years are spent with the colours, the next 4 on leave. During the last 5 years they are only liable for service in case of war.

Infantry.—There are 209 regiments, each of 4 battalions, of 4 companies and a non-combatant company. These regiments comprise 12 of imperial guard, 16 grenadiers, 181 line infantry. Guard regiments have titles only, the rest (1 to 16 grenadiers and 1 to 180 line) have a geographical title as well as a number. The peace and war establishments of a regiment are as follows:—

	Peace.	War.
Officers	70	79
N.C.O.'s and men (combatants)	1816	3874
Horses	25	158
Carriages	...	77

Rifles are regarded as light troops, and are supplied with recruits of superior stamp. They consist in peace of 36 two-battalion regiments and 32 independent battalions, having on mobilization 4 four-battalion regiments, 32 two-battalion regiments, and 32 independent battalions. The magazine rifle, 1891 pattern, calibre 0·299 in., weighs with bayonet 9 lb 12 oz., has a muzzle velocity of 2000 f.s., and is sighted to 3000 paces. Every infantry regiment carries in the field 1280 light and 256 heavy spades, 320 light and 128 heavy axes. The Cossack infantry consists in war of 16 Kuban and 4 Transbaikal battalions. The reserve infantry cadres maintained in peace consist of 82 battalions in Europe, 26 battalions in the Caucasus, and 15 battalions in Asia, to be expanded on mobilization to 264, 74, and 51 battalions respectively. The fortress infantry is organized in peace in 1 regiment of 5 and 17 regiments of 2 battalions, each of 5 companies. On mobilization these expand into 31 regiments of 5 battalions. The regiment takes its title from its fortress. The militia is intended to be organized in 640 battalions in war, and to be brigaded in 2 categories, each of 320 battalions.

Cavalry.—The regular cavalry consists of 68 regiments of 4 or 6 squadrons, and 2 independent Asiatic divisions of 2 squadrons. The establishment of regiments is as follows:—

	Peace.		War.	
	4 squadrons.	6 squadrons.	4 squadrons.	6 squadrons.
Officers	32	38	30	36
N.C.O.'s and men (combatants)	706	1027	629	920
Horses	585	905	676	1016
Carriages	...	...	23	29

Each squadron carries 20 light spades and 20 light axes on the saddle. Pioneer detachments with a demolition equipment are provided in the case of regiments on the western frontier. The Cossack cavalry supplies 317 squadrons in peace and 905 in war. Each regular regiment has a depot cadre, which on mobilization forms 2 squadrons. The Cossack establishments supply in war 43 depot squadrons, to train men and horses for the active units. On general mobilization it is contemplated to form 80 squadrons of militia cavalry.

Artillery.—The field and mountain artillery consists of 52 brigades—3 guard, 4 grenadier, 45 line—attached to infantry divisions, together with 53 batteries, of which 7 form the Turkestan brigade, and 12 form 2 East Siberian brigades, the remainder being classed as "independent." An artillery "brigade" varies in strength from 9 batteries (guard, grenadier) to 4 batteries (2nd East Siberian). Batteries are classed according to their armament as heavy, light, mountain, and howitzer. Batteries of the first 3 classes have each 8 guns; howitzer batteries have 6. The following are the particulars of the equipments:—

	Heavy.	Light.	Mountain.	Howitzer.
Calibre (in.)	4·2	3·42	2·5	6
Shrapnel (lb)	28	15·4	8·9	59†
Muzzle velocity (f.s.)	1450	1700	1143	760
Projectiles carried	108	150	128	92
Load behind team (cwt.)	42½	37½	194*	41½

* Weight of gun, lb. † High explosive shell.

A field battery carries 32 spades, 24 axes, and 4 pickaxes for entrenching purposes. New equipments are being tried and will be gradually introduced. The howitzer artillery consists of 7 regiments, of which 1 to 5 have 4 batteries each, and the remainder 2 batteries. There are also 2 batteries forming part of the 1st East Siberian brigade. The regular horse artillery numbers 28 batteries (5 guard) and 3 independent horse mountain batteries. The horse batteries are organized in divisions of 2 batteries and attached to cavalry divisions. The Cossack horse artillery batteries number 20 peace and 38 in war. The reserve field artillery in peace consists of 7 brigades, each of 2 divisions of 2 or 3 batteries, in all 41 batteries, expanding on mobilization to 164 batteries. The depot field artillery force is organized in peace cadres, forming 3 brigades of 3 batteries, 5 independent batteries, and 1 horse artillery battery, expanding in war to a total of 56 batteries. It is proposed, when the militia is called out, to form 80 militia batteries, organized in 40 regiments attached to the 40 divisions of infantry. The fortress artillery contains 56 battalions of 4 companies, 4 siege battalions of 4, 3, or 2 companies, 10 independent companies, and 5 sortie (field) batteries expanding into 16 batteries. The establishment of a fortress or siege battalion is:—

	Peace.	War.		
		Battalions of		
	Company.	2 Cos.	3 Cos.	4 Cos.
Officers	3	11	16	21
N.C.O.'s and men (combatants)	112	654	983	1310

The siege ordnance consists of 4·2-in., 6 in., 8-in. guns, and of 3·4-in., 8-in., and 9-in. (screw) mortars. The garrison and coast defence ordnance includes 14-in., 11-in., and 9-in. guns (1877), 11-in. (1886), 10-in (1895), and 6-in. Q.F. (Canet) guns. A militia force of foot artillery, consisting of 10 battalions, each numbering 24 officers and 1308 N.C.O.'s and men, is to be formed in war.

Engineers.—The sapper and pontoon battalions and the engineer parks are in peace time administered in 7 brigades. In war the units are distributed among the field and other troops. There are 25 sapper battalions in Europe and 4 in Asia, 8 pontoon battalions and 7 field parks. The sapper battalion has usually 3 sapper companies and 1 telegraph company. Its usual establishment strength is:—

	Peace.	War.
Officers	22	26
N.C.O.'s and men (combatants) .	488	937
Horses	14	321
Carriages	...	119

A pontoon battalion carries from 640 to 400 yards of bridge equipment. There are 7 railway battalions, 4 in Europe and 3 in Asia. The latter are kept at war strength: 30 to 35 officers and 1300 to 1560 N.C.O.'s and men combatants. There is in peace an instructional balloon park, which would form detachments in war for armies in the field.

Higher Organization for War.—The active army in Europe and the Caucasus supplies 24 army corps composed of 51 infantry and 23 cavalry divisions and 2 rifle brigades. There are also 1 independent rifle division, 5 independent rifle brigades, and 2 independent cavalry brigades, together with a large body of active troops not included in the higher units. The empire is divided into 12 military districts and 1 province, subdivided into 23 local brigades.

The approximate total strength of the combatant forces on a war footing is as follows:—

	Battalions or Squadrons.	Guns.	Officers.	N.C.O.'s and Men.
I. *Field Army*—				
Infantry . .	965	...	19,454	952,706
Cavalry . .	730	...	3,728	109,916
Artillery . .	...	3762	4,484	184,096
Engineers .	...	...	1,078	69,981
Total . .	...	3782	28,742	1,266,701
II. *Field Reserves*—				
Infantry . .	...	...	10,572	661,152
Cavalry . .	...	...	2,266	85,090
Artillery . .	...	1420	1,403	51,196
Engineers .	...	...	137	6,001
Total . .	...	1420	14,348	776,439
III. *Fortress Troops*—				
All arms . .	...	128 (field)	4,357	235,861
IV. *Local Troops*—				
Cavalry and Infantry .	...	...	379	29,690
V. *Depot Troops*—				
All arms . .	...	462	5,814	330,826
VI. *Militia*—				
All arms . .	...	640	10,752	673,886
Grand Total	1715	6432	64,392	3,310,203

The conditions of the Russian empire render a rigid territorial system such as that of Germany impossible. Large Asiatic garrisons have to be provided, which, until the completion of the Siberian railway, must be mainly transported and supplied by sea. Native troops in considerable numbers are maintained, and have to be brought into the general system. Thus the military problems of Russia approximate more closely to those of Great Britain than to those of any other Power. (G. S. C.)

TURKEY.

The Turkish military forces are organized on a territorial system, the empire being divided into 6 districts (ordu), of which the headquarters are (1) Constantinople, (2) Adrianople, (3) Monastir, (4) Erzinjan, (5) Damascus, (6) Baghdad. The Yemen and Hejaz form a separate ordu, whose troops are recruited from (4) and (5). On account of the defective state of the internal communications and other circumstances, the territorial system is not rigidly adhered to, and even in peace time there is a considerable interchange of troops in the military districts. All Mussulmans are liable to military service, but the nomad Arab tribes are not regularly recruited, and many of their men evade the conscription. Liability to service commences at the age of 20, and lasts 20 years. The armed strength is divided into 3 categories, in which the period of service is nominally as follows:—

I. Nizam (active army)	with colours . .	4 years.
	in reserves . .	2 ,,
II. Redif (landwehr)		6 ,,
III. Mustahfiz (landsturm) . . .		6 ,,

The period of 4 years with the colours is sometimes varied, and the nizam reserve is liable to be recalled at any time. Between 130,000 and 140,000 men become liable to service in each year, and about 50,000 join the nizam force. Those not drawn are exempted from colour service, but receive some small training.

Cavalry.—The nizam cavalry forms 38 regiments of the line and 2 of the guard, each consisting of 4 squadrons and 1 depot squadron. Regiments 1 to 36 form 6 cavalry divisions, one for each of the 8 ordus. There is no redif cavalry, but a tribal militia force (Hamidieh), consisting of 48 regiments, is formed somewhat on the lines of Cossacks, the tribes supplying their own horses and equipment, and arms being provided by the Government. The war establishments of nizam cavalry are:—

	Officers.	N.C.O.'s and Men.
Squadrons	6	153
Regiments	39	847

Peace establishments are generally low and vary considerably, especially in Hamidieh regiments.

Artillery.—The Turkish artillery has been generally the most efficient of the three arms. Each of the ordus 1 to 5 has 1 battalion of horse artillery and 3 brigades of field and mountain artillery. A brigade consists of 2 regiments of 2 battalions of 3 batteries. The battery on a war footing has 6 guns. Thus each of these ordus should have—

	Batteries.	Guns.
Horse artillery	6	18
Field ,, ...	30	180
Mountain ,, ...	6	36
Total . .	39	234

To the 8th ordu 2 regiments of 2 battalions are allotted, each regiment having 12 field and 2 mountain batteries. For the Yemen and Hejaz divisions 2 field and 3 mountain batteries are provided. The total number of batteries is approximately:—Horse, 15; field, 169; mountain, 42.

A field battery on a war establishment is supposed to contain 4 officers, 133 N.C.O.'s and men, and 100 horses. Peace establishments vary considerably in the different ordus. Horse artillery is armed with 7·5-cm. guns, field artillery with 8·7-cm. guns, and mountain artillery with 6·9-cm. guns, all of Krupp manufacture. Fortress artillery is partly raised in the several ordus, and partly recruited specially for the ordnance department. The ordus are supposed to provide 84 companies, the ordnance department 20 battalions, comprising 74 companies. The fortress artillery is mainly concentrated at Constantinople, in the Bosphorus and Dardanelles defences, in the Bulair lines and at Erzeroum.

Infantry.—The nizam infantry consists of 69 regiments, 15 rifle battalions, and 1 battalion of mountain infantry. In all there are about 284 nizam battalions. There are 12 local battalions of militia in Tripoli. A brigade consists of 2 regiments of 4 battalions; a division consists of 2 brigades and 1 rifle battalion. Each ordu contains 6 line regiments and 2 rifle battalions. The nominal war establishments of line and rifles are:—

	Officers.	N.C.O.'s and Men.
Company	4	223
Battalion	24	698
Regiment	108	3658

The redif infantry is organized in 88 regiments and 652 battalions. Each of the ordus supplies 6 regiments of 4 battalions. Redif troops nominally belong to the 2nd line, but are frequently embodied in peace time, and employed outside their territorial districts. Small peace cadres are permanently maintained. The war establishment is intended to be the same as that of the nizams, but redif battalions may be 1200 strong. The nizam infantry is armed with the Mauser magazine rifle, calibre 0·302 inch, weighing with bayonet 10 lb 7¾ oz. Other forces are not yet fully rearmed with recent weapons.

Engineers, like artillery, are partly organized in the ordus and partly recruited from the ordnance department. The ordus 1 to 4 provide each 1 battalion of 4 companies of pioneers, and 1 telegraph company; the remaining ordus have each 1 company only. The 2nd ordu has in addition a pontoon train under the ordnance department. There are two regiments of 3 battalions of 2 companies and 1 torpedo battalion. The establishment of an engineer company is about 200 men of all ranks, and of a telegraph company about 106.

Higher Organization.—Each ordu is supposed to form a nizam army corps of 2 divisions, and ordus 1 to 5 also supply 4 divisions of redifs. A nizam division would probably consist of 16 battalions of infantry, 1 battalion of rifles, and 1 regiment of field artillery. A cavalry division might consist of 6 regiments and 1 battalion of horse artillery—24 squadrons and 18 guns. A nizam army corps would comprise 2 infantry divisions and 1 cavalry division. The redif divisions would depend on the nizam army for their artillery, and there is not sufficient nizam cavalry to enable them to be formed into army corps. The army corps organization, however, has not been wholly naturalized in the Turkish empire, and is not well suited to its conditions. The combatant forces of Turkey number about 700,000 men, exclusive of a large number of mustahfiz, who cannot be said to be organized, but who would provide able-bodied men partly trained.

(G. S. C.)

Switzerland.

The Swiss army is a purely militia force, receiving only periodical training, but based upon the principle of universal service. Liability begins at the age of 20 and lasts for 25 years. Cavalry men receive a recruit's course of 80 days' training on joining, and subsequently a repetition course of 10 days in each year, until the end of the 11th year. Artillery and infantry undergo recruits' courses of 55 and 45 days respectively, and a repetition course of 18 and 16 days in every alternate year till the end of the 12th year, when they pass into the landwehr, and receive 6 and 5 days' training every fourth year. The Confederation supplies certain units which are recruited throughout the country. The rest of the army is recruited in 8 territorial districts. The armed strength consists of (1) the active army; (2) the fortress garrison; (3) the landwehr; (4) the landsturm. The active army is organized in four army corps which draws only to a small extent upon the landwehr. The fortress garrisons are made up of active troops (*élite*) and landwehr. The rest of the landwehr is organized in regiments, squadrons, companies of position artillery and engineers, and administrative units. The landsturm includes all able-bodied men between 17 and 50 who are not included in the active army and landwehr, volunteers under 17 and over 50, and officers up to 55 years of age. It is divided into two classes, of which the first consists of all men under 20, who on mobilization join the active army as recruits. The 2nd class, consisting of men of 20 and upwards, is divided into the "armed landsturm" and the "auxiliary troops." The armed landsturm forms 96 fusilier battalions of 3, 4, or 5 companies, 23 carabinier companies, and 26 companies of position artillery. It is inspected and drilled on one day in each year. The "auxiliary troops" form 410 pioneer companies about 200 strong, and "special detachments" for administrative services.

Cavalry.—The cavalry of the active army consists of 24 squadrons of dragoons and 12 companies of guides, the former being organized in 8 regiments of 3 squadrons. The landwehr cavalry supplies the same number of units, but has no horses. A dragoon regiment has 17 officers and 358 N.C.O.'s and men. Of the 12 companies of guides, 8 are attached to divisions and have the same strength as a squadron of dragoons. Cavalry horses are kept for a year in the remount depots before being issued to recruits. After passing through the recruit's course, the cavalry man takes his horse to his home, paying half its cost as security. This sum is repaid by the state in "yearly instalments," and at the end of the 10 years' service the horse becomes the property of the man. Dragoons are armed with sword and a magazine carbine, weighing 7·05 lb., calibre 0·295 in., muzzle velocity 1800 f.s. The Swiss cavalry, on account of its brief training, is intended to be employed almost wholly in reconnaissance and as mounted infantry.

Artillery.—The active artillery comprises 56 field and 4 mountain batteries, each of 6 guns; there is no horse artillery. For fortress work there are 8 companies, 3 observation companies, and 2 machine gun detachments. The landwehr provides parks, ammunition trains, and 15 position companies. The 56 field batteries form 12 regiments, 8 of which, each consisting of 2 brigade divisions of 2 batteries, are attached to the 8 divisions. The remaining 4 regiments each consist of 2 brigade divisions of 3 batteries, allotted as corps artillery to the 4 army corps. A regiment of 4 batteries contains 23 officers and 652 N.C.O.'s and man, with 340 horses and 24 guns. The field artillery is armed with a 3·31-in. Krupp gun, firing a 14·8-lb shrapnel, with a muzzle velocity of 1590 f.s. The mountain gun, calibre 2·95 in., fires a shrapnel of 10·14 lb, with a muzzle velocity of 1004 f.s. There are 5 brigade divisions of position artillery, each composed of 2 active companies and 3 of landwehr. A brigade division numbers 41 officers and 778 N.C.O.'s and men. Its armament consists of 16 12-cm. guns, 12 12-cm. mortars, and 12 6-cm. guns. Of the position artillery, 1½ brigade divisions are allotted to the St. Gothard and St. Maurice defences; the rest is available for employment with the field army. There are 3 brigade divisions of fortress artillery attached to the defences above mentioned. Artillery horses and those of the train are hired when required.

Infantry.—The active infantry consists of 96 fusilier and 8 carabinier battalions, each containing 25 officers and about 730 N.C.O.'s and men, or 720 combatants in all. A fusilier regiment consists of 3 battalions. The landwehr infantry consists of 66 fusilier and 8 carabinier battalions. Throughout the army there is only one establishment—that laid down for war. The active army and landwehr infantry are armed with the Schmidt magazine rifle, calibre 0·295 in., weight with bayonet 10·43 lb, muzzle velocity 1900 f.s. The landsturm infantry have the Vetterli rifle, calibre 0·410 in., weight with bayonet 11·46 lb, muzzle velocity 1411 f.s.

Engineers.—The engineers of the active army comprise 8 half-battalions of 2 companies of sappers, 4 bridging detachments of 2 pontoon companies, 4 telegraph companies, 1 railway battalion of 4 companies, 1 balloon company, and 3 fortress companies. The landwehr provides 16 sapper companies, 2 bridging detachments, 4 telegraph companies, and 4 railway companies.

Higher Organization.—The field army is organized in four army corps of 2 divisions, with corps troops. Each division contains 2 infantry brigades of 2 regiments of 2 battalions, together with 1 guide company, 2 brigade divisions of field artillery, a carabinier battalion, and half a battalion of engineers. The 8 divisions are recruited in 8 territorial districts. On mobilization the active army absorbs 230 officers and 5736 N.C.O.'s and men from the landwehr. The approximate total strength of establishments is as follows:—

	Officers.	N.C.O.'s and Men.	Total.
Active army	4522	97,169	101,691
Active landwehr	230	5,736	5,966
Fortress garrison	224	5,085	5,309
Fortress landwehr	314	8,462	8,776
Landwehr troops	1751	43,159	44,910
Total	7041	159,611	166,652

In addition, the "armed landsturm" numbers about 53,500 men of all ranks. The pioneer companies supply about 104,000 men, and the special detachments about 114,000 men. The former have received extremely little training, the latter consist of men told off as far as possible for miscellaneous duties to which they are accustomed.

The Swiss army is a highly organized force, which, regarded as a militia, has no equal. The amount of training imparted to it is necessarily limited, but is made as thorough as possible; and the results obtained, as shown by manœuvres, are surprising. Against the small amount of actual drill must be set the long service of 11 or 12 years passed in the same unit. The men thus acquire a solidarity which cannot be at once attained in bodies made up from reserves on mobilization. Composed of mature and hardy men inured to the conditions of a mountainous country, the army is unquestionably a powerful defensive force, reflecting the sturdy national patriotism of the Swiss, and capable of offering a strong resistance to external aggression. The total annual military expenditure of Switzerland is under £1,000,000, which approximately represents the cost of the British volunteers.

(G. S. C.)

JAPAN.

Japanese military organization on Western lines may be held to date from 1873. Involving as it did the disappearance of the *samurai*, or feudal soldier *par excellence*, the altered state of things occasioned some trouble at first, but within three years the new model got into fair working order and has now been accepted with sober enthusiasm by the people. At the beginning an advisory board of British experts was set up. Then this gave way to the *mission militaire* of French officers and Italian artillerists in the arsenal at Osaka. These were in turn replaced by a staff of German specialists. Finally, since the period of the Chinese war, the Japanese have felt strong enough to dispense with all foreign assistance and to organize their army for and by themselves.

Conscription.—Every male of the age of twenty is liable to the conscription, provided he is passed by the doctor, is not (under safeguards) the sole breadwinner of his family, suffers from no permanent illness or disablement, is not a criminal, and is not undergoing a very specialized curriculum of education. The conscripts are chosen by lot. The minimum height for the infantry, cavalry, and army service corps is 5 feet 2 inches; for the artillery and engineers, 5 feet 4 inches. The number of eligibles is estimated at 427,000 a year, of whom 60,000 are actually taken for the colours, and 131,300 for the depot or supernumerary forces. There is an elaborate system of volunteering, devised to secure the thorough training of the exempted students and of natives who have been resident in foreign lands, who on their return to Japan at the age of thirty-two are drafted into the territorials.

Service.—There are four grades of service, namely—(*a*) with the colours for three years; (*b*) with the first reserves for 4⅓ years, who are called up twice during their full term for three or four weeks at a time; (*c*) with the second reserves for five years (the *landwehr*), who are called out twice for two weeks at a spell during their full term; and (*d*) with the territorial troops (the *landsturm*) up to the age of forty. Besides these grades there are two classes of supernumeraries (the depot), the first comprising men who, though physically qualified and otherwise liable to serve, have not been called up for service with the colours; the second, men who have not only escaped the lot for the colours, but also service with the first supernumeraries. The first depot serve for 7⅓ years, with 150 days' training during the full term, of which ninety days are usually required during the first year; the second depot serve for 1⅓ years, without any training, as a rule, during the period. Ultimately both classes pass into the territorial army. Their chief purpose is to fill such vacancies as occur in the ranks of the regulars.

Personnel.—The conscript private becomes first a second-class soldier, then first-class, then upper, promotion depending upon proficiency and good conduct. The non-commissioned steps are corporal, sergeant, sergeant-major, and special sergeant-major, with specified periods of service in each grade, promotion resting solely upon merit. Officers are recruited from graduates at the Officers' College—to which students go up either directly from one of the six local preparatory schools or the central preparatory school at Tokyo, after passing an examination in either case—but no commission is issued until the Staff Council are satisfied of the candidate's competence and progress. For the higher and specialized training and education of commissioned officers there are several schools, of which the most important is the Army College, in which instruction is given for the superior ranks and staff appointments. Others of these institutions are the Toyama School of Musketry and Strategy, the School of Artillery and Engineers, the Field Artillery School, the Garrison Artillery School, the Cavalry Practical School, the Army Service School, the Army Medical School, the Veterinary School, the Arsenal School, and the School of Military Music. The ranks of officers are, in their order, second-lieutenant, first-lieutenant, captain, major, lieutenant-colonel, colonel, major-general, lieutenant-general, general, and field-marshal. Up to and including the grade of captain, promotion is partly by seniority and partly by merit; but above that rank promotion takes place by merit alone. An officer who never rises beyond his captaincy is compulsorily retired at the age of forty-eight. The pay of a private runs from 1s. 10d. per mensem for a second-class to 3s. 0½d. for an upper soldier; of a non-commissioned officer from 9s. 2d. per mensem for a second-class corporal to 28s. 6d. for a first-class special sergeant-major, besides rations, uniform, and quarters. Officers are paid at rates varying from £34 per annum for a second-lieutenant to £71 for a captain, £115 for a major, £238 for a colonel, and £600 for a general.

Organization.—Taking the army as a whole, it is composed of twelve divisions, numbered 1 to 12, and one division of guards (the Imperial Guard). Each division is commanded by a lieutenant-general, is stationed permanently in an assigned district, comprises four regiments of infantry, one regiment of cavalry, one regiment of field artillery, one battalion of engineers, one battalion of army service, and is in itself a complete fighting unit. An infantry regiment is made up of four battalions of three companies each; a cavalry regiment of either three or four squadrons, with 100 sabres to each; and a field artillery regiment of six batteries of six guns each. A battalion of engineers is composed of three companies, or 600 men; a battalion of army service of 300 men. The normal strength of a division is thus made up, excepting the division of guards, which is somewhat smaller:—

Infantry	9,600
Cavalry	300
Engineers	600
Army Service	300
	10,800 men and 36 guns.

Of mountain artillery there are six regiments, or 216 guns in all. The total force of field artillery amounts to seventeen regiments, or 612 guns; whilst the total strength of cavalry stands at about 5000 sabres. Over and above their normal strength, several of the divisions (the Imperial Guard, and the First, Fourth, Fifth, Sixth, Seventh, Tenth, and Twelfth) are furnished with extra corps, mostly of artillery, for the garrisoning of the forts at Tokyo, Yura, Kure, Geiyo, Saseho, Tsushima, Hakodate, Maizuru, and Shimonoseki; the additional complement of the guards consisting of a brigade (two regiments) of cavalry, a brigade (three regiments) of field artillery, and one battalion of railway engineers. The present peace footing may be taken at 100,000 men; but in 1905, when the whole scheme of readjustment will be completed, the *peace strength* will amount to 150,000 men of all ranks and 30,000 horses, the *war strength* to 500,000 men and 100,000 horses. The guards are recruited from every part of the empire; the divisions, from the districts to which they are attached. Formosa is garrisoned by a mixed brigade, supplied by the divisions in rotation, composed of two regiments of infantry, two squadrons of cavalry, three batteries of field artillery, half a battalion of engineers, and half a battalion of army service. Testimony is universal to the exceptional efficiency of the Medical Service Corps, which is distributed in the proportion of 100 surgeons to each division, with a complete equipment for field hospitals, bandaging stations, special hospitals, and the like. There is also a Red Cross Society, in addition to a great hospital at Tokyo, a large staff of trained nurses of both sexes, and two hospital ships designed and furnished for the transport of the wounded. The total cost of the whole army is a trifle over 37,000,000 yen, or £3,700,000 per annum.

Staff.—Supreme control is vested in the emperor, who is the commander-in-chief, but he is actively assisted by a general staff (with a field-marshal for chief and a general or lieutenant-general for vice-chief), the War Office, and a board of field-marshals. In addition to the transaction of general business, the general staff supervises the survey, trigonometry, cartography, and topography departments, and directs the Army College. The head of the War Office is a general on the active list, who has *ex officio* a seat in the Cabinet and is not affected by ministerial changes. There is a Tokyo Defence Office, under a lieutenant-general, specially charged with the defence of Tokyo Bay, and similar duties in regard to the other forts are entrusted to three major-generals, with headquarters respectively at Yokohama, Shimonoseki, and Yura. All questions concerning arms and ammunition are referred to expert committees of artillery and engineering, and there is besides a Remount Office. For military purposes the whole empire is divided into eastern, western, and central districts, each under the command of a general or lieutenant-general.

Arms.—Excepting in time of war, the Japanese are able to make all their munitions in the arsenals at Tokyo, Osaka, and Taipeh (Formosa). The infantry carry the repeating rifle designed by Colonel Arisaka, and the field and horse artillery are at present (new weapons, Arisaka pattern, are in hand) equipped with field guns (weight about 6 cwts.) and mountain guns (weight, 2 cwts.) of the same calibre (2·955 inches) and firing similar ammunition, of which the common shell weighs about 9½ lb.

For a full account of the military system under the *ancien régime* and further details about the existing organization, see under JAPAN.

[For *Egyptian Army* see EGYPT. For other Armies see under the separate headings for each country.]

ARMOUR.

I. Body Armour.

SINCE the publication of the article in the ninth edition of this work on "Arms and Armour," the subject has been closely studied by experts, and is better understood generally than was the case five-and-twenty years ago. The tendency at present is to appreciate beauty of design and excellence in workmanship rather than historic interest or sentiment. This tendency, which especially exists among Continental collectors, may give place some day to a demand for pieces which speak more directly of the warrior fighting in the field than of the skill of the artificer in the workshop; but the entire value of such pieces depends on their genuine character, and this is more difficult to establish in plain than in elaborate workmanship. Suits of armour which embody both skill and sentiment can hardly fail to be sought after at all times. Of these, putting aside the question of armour known to have belonged to some celebrated man, the suits which are of by far the most value are those few which still remain of the 15th century, commonly called Gothic suits. These are appreciated not only on account of their rarity, but because of their singular beauty in design and excellence of manufacture. A few of these exist in the Tower of London, but the most beautiful suit in England is a mounted one in the Wallace collection. The monument of Count Otto IV. von Henneberg, executed after 1480, furnishes a very good example of 15th-century armour of the highest class. The photograph from which Fig. 1 was reproduced is from the cast in the South Kensington Museum. The effigy of Earl Richard in Warwick chapel is another beautiful example. Of this Mr Starkey Gardner says that it looks like the work of nature rather than art. Most readers must be familiar with another example in Albert Dürer's print of "the Knight, Death, and the Devil." Armour culminated as to completeness, though it lost in beauty, at the end of the 15th century, when the so-called Maximilian type came in. In this the pointed toe gave place to one of extravagant width. Of this armour many fine examples exist, as the Tower of London includes several suits

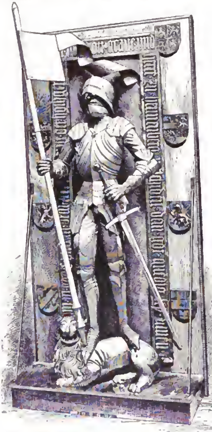


Fig. 1.—Gothic style of armour. Monument of Count Otto IV. von Henneberg.

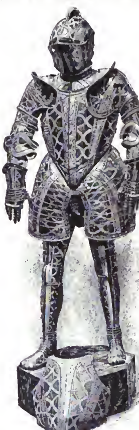


Fig. 2.—Suit by Jacob Topf, nearly complete; the gorget does not belong to it. Below is the placcate.

which belonged to Henry VIII. Most high-class armour up to this time was made on the European Continent; that represented in the Warwick effigy is Italian, while the armour of Henry VIII. is chiefly German. Fig. 2, however, shows a beautiful suit or half-suit, still extant, which belonged to Sir Christopher Hatton, and was the work of a celebrated English armourer, Jacob Topf. The different classes of armour may be broadly distinguished as follows:—(1) *War harness* was seldom complete for the rider, and little was used on the horse in actual war. On foot, little armour could be worn below the knee—Sir Christopher Hatton's is an example of a very handsome suit for a mounted knight in war. (2) *Tournament armour.*—In the lists, not only would complete armour be used, but additional pieces of special weight. For jousting, the rider required to be quite rigid, in order to deliver the impetus of horse and man in a sharp blow through the end of the lance, so as to strike the adversary out of his saddle, or break the lance. Aim was generally taken at the helm (see a paper by Lord Dillon in the *Archæological Journal*). The rider sat against the cantle of the saddle with straight knees and stirrups home. Hence the helm in the 15th century was a rigid steel case resting on the shoulder. In the 16th this was superseded by extra pieces, chiefly one termed the grand guard or volant piece, protecting the chest and part of the face. (3) For *fighting in the lists on foot*, the armour was eventually carried inside the legs and arms, and under the seat, in plates fitting so closely that a penknife would scarcely find entrance. Of this an admirable example may be seen at the Tower in a suit made for Henry VIII.

The following examples of armour may be specially noted:—

The Tower of London.—The above-mentioned suits of Henry VIII., mounted and dismounted, especially that made by Conrad Seusenhofer; also, Leicester's suit; a German tilting saddle in which the rider sat, or rather stood, with his legs in sockets; a few samples of jacks or brigandines, consisting of plates sewn to texture, one on an Elizabethan archer; also, two long bow staves recovered from the *Mary Rose* sunk at Spithead.

The Wallace Collection.—The Gothic suit above mentioned, and many suits possessing their original appearance in unusual measure, owing to careful preservation and gentle cleaning.

The Rotunda Museum, Woolwich.—Armour left behind in a guard-room at Rhodes by the knights on their evacuation in 1522, which constitutes the greatest recent "find." It consists chiefly of salades and 15th-century pieces. The Brocas tilting helm, unsurpassed by any, is also at Woolwich.

Windsor Castle.—Tilting pieces and armour about the close of the 15th century.

Warwick Castle.—Curious old closed chamfron.

Canterbury Cathedral.—Tilting helm, a short surcoat termed a jupon or cyclas, and gauntlets of the Black Prince; the last are perhaps the earliest extant.

Westminster Abbey.—Saddle and shield of Henry V. In the Chapter House is the only known sample of an old English arrow. Most of the armour placed over tombs and in churches is "mortuary," *i.e.*, made specially for the purpose and generally good for nothing, but some beautiful pieces have been thus deposited.

Armour ceased to be used by combatants generally in the 17th century, but it has never been entirely given up, and has in exceptional cases been used up to the present day. The cuirasses worn by heavy cavalry are undoubtedly only used for display—the Life Guards left them behind when they went on active service to Egypt and South Africa; but helmets are retained for protection against sword cuts in hand-to-hand fighting, and it seems unlikely that anything can supersede them. The growing power of fire-arms, however, drove out armour. First, it was given up for the limbs, and thickened so as to be bullet-proof for the breast; when horsemen engaged hand to hand, with pistol and sword, bullet-proof armour must continually have saved life. Breastplates of the 17th century frequently have indentations made by bullets. Some of these are no doubt proof marks, but by no means all. One pair of plates at Dover Castle has three bullet marks. In the siege of Athlone in 1691, complete armour was worn by a special body of men. Very heavy helmets and back plates were worn by sappers. A picture of the siege of Rome in 1848 shows a sapper in a special helmet worn for protection under fire. Hard steel breastplates were produced by Dowe, Maxim, and others in 1894. They stopped modern bullets, but weighed over ten pounds, which is too heavy for wear. Still, portable shields might be used in siege works, and steel shields are employed on gun-carriages and mountings. Against sword cuts, especially the sharp draw-cuts of an Eastern blade, mail is an efficient protection. Dervish warriors wore mail in the battle of Omdurman in 1898. Mail has been recently applied to the shoulders of the British cavalry, and one incident showing the value of mail may be recorded. In Egypt in 1885 an officer's wife purchased a patch of chain mail, which she insisted in sewing inside the breast of the uniform worn by her husband, a lieutenant of the 5th Bengal Cavalry. This regiment was engaged hand to hand shortly afterwards, and a spear-thrust aimed at his breast was stopped by the mail; he came out unharmed, with the spear-head broken off and hanging in it. Lastly, mail has been specially made of hard steel rings for gold-diggers, and the English detective department possesses such mail for wearing, if needed, inside a coat.

II. Ships and Forts.

The fact that armour for the defence of the soldier's body had failed to resist musket balls, and had gone out of use, probably tended to prevent its being proposed and tried on a larger scale for the protection of ships and forts. Nevertheless experiments were made with regard to both in the United States in 1812, 1841, and 1853, and in England in 1827 and 1840. In 1855 the French employed floating batteries at Kinburn; and before the end of the Prussian war both France and Great Britain had iron-plated batteries afloat. The British *Warrior* and French *Gloire* classes were ordered in 1858, and the United States coast vessels, termed monitors, were begun in 1861. The future use of armoured ships was indeed assured by the havoc wrought among unarmoured vessels by the Confederate ship *Merrimac*, protected by impromptu armour made of railway iron rails. The application of armour plates to vessels is dealt with under Ship Construction, the object of the present article being to trace the development of the actual armour itself, whether intended for ships, coast defences, or inland forts.

For many years after the introduction of armour neither plate nor shot gave promise of the powers since attained. The shock of impact shattered or flattened the shot, and the harder plates were fractured to such an extent that wrought iron was adopted. For many years the only improvements made consisted in rolling plates of increased thickness and size, and in employing with them such bolts and backing as best enabled them to bear attack. Thus plates were applied in several thicknesses, sandwiched with thin layers of wood between them, and the so-called "Palliser English" bolt was introduced, ingeniously devised to avoid nipping and local strain, with a spherical head which accommodated itself to any slight displacement of the plate. This soft armour encouraged the development of hardness rather than toughness of shot; consequently, although steel projectiles held together better than those of cast iron, the latter, when made on Palliser's system with points and heads hardened by chilling, penetrated so well that they were largely adopted by all Powers, and no fundamental change either in shot or armour took place in naval armaments till 1876. In 1868, however, an entirely new form of armour for land defences had been devised, which, although it has never attracted much attention in England, is used almost universally in European coast forts. It was proposed and made by Gruson of Magdeburg, and consists of massive shields of chilled cast iron, which are easily made of any required form. No backing or bolts are used, the shield being built up of heavy blocks, if possible cast on the spot, which are keyed together, and constitute the entire parapet (see Fig. 3). The metal can be made of thickness varying according to the supposed needs of each part of face or roof, and the breech-loading ordnance, at that time existing on the Continent, but not in England, allowed the use of shields sloping down forward at the gun forts in curves well adapted to cause shot to glance off them.

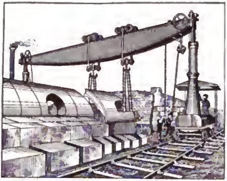


Fig. 3.

In British coast forts vertical walls were adopted, covered with wrought-iron plates, either applied in a single thickness, or in successive layers sandwiched with wood or concrete (see Fig. 4). Thus British coast armour differed fundamentally from that employed by other nations, and this difference is maintained to the present time. These two kinds of coast shields deserve attention as furnishing examples of the opposite extremes in character, and as justifying the classification of armour plates into "soft" and "hard" kinds, a distinction which must be kept in view in order to understand the power of artillery fire, and the behaviour of armour when attacked by it. Soft armour plates, such as those of good wrought iron, do not break under the impact of shot, but yield by perforation. Thus a projectile with sufficient striking energy passes through soft armour, making a more or less clean hole, but leaving the plate practically as strong as before. A shot, however, that fails to perforate, effects nothing, lodging harmlessly in the shield. Hard armour, on the other hand, of which chilled iron furnishes the most extreme example, refuses to yield by perforation, and breaks up the shot on impact; but it gradually becomes disintegrated, the whole mass before long parting in fragments. Hard armour offers a complete defence against a few rounds from very heavy guns, men and ordnance covered by it being entirely protected until their shield is destroyed. On this account chilled iron shields have been used to protect coast artillery from the few rounds that the heavy guns of men-of-war may be expected to deliver during an attack of limited duration. Notable examples of Gruson's shields and forts are the St Marie battery near Antwerp (see Fig. 3), cupolas at the entrance of the Weser near Bremerhaven, and two turrets defending Spezia harbour, each mounting two 119-ton Krupp guns (see Fig. 5). The joints shown in this figure indicate that the turret roof is built up of fifteen sector-shaped pieces and two centre plates of semicircular form. Before adoption a sector piece was subjected to three blows from projectiles fired from an Elswick 100-ton breech-loading gun. A fourth round indeed was afterwards delivered, as well as some rounds from 15-cm. (5·9 in.) guns. This shield was fractured in several directions, but the fragments remained *in situ*, and the defensive power of the shield was probably but little diminished, and would continue until some large fragments should become displaced. Soft armour, until recently best exemplified by wrought iron, but now by soft nickel steel, exhibits its capacity most fully in inland fortifications, where it may be called upon to resist the breaching attack of siege guns of such limited weight and power as not to be able to perforate it completely. First-class soft armour might bear such an attack for hours and days, or perhaps even for weeks. The continued breaching attack of inland forts by siege guns of limited weight, and the brief attack of coast shields by the very heavy guns of battleships, illustrate the conditions which bring out most completely the powers of soft and hard armour. Between these lie innumerable

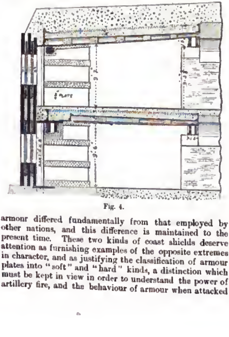


Fig. 4.

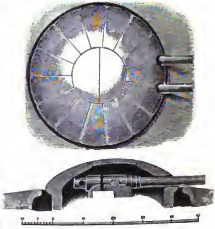


Fig. 5.

cases; for example, the armoured belt of a cruiser and that of a battleship. The former is the thinner, and more liable to be overmatched by a shot, but a cruiser is not likely to be long exposed to attack. The thick belt of a battleship is less likely to be overmatched, but the vessel is more likely to be kept in continuous close action; consequently the belt of the cruiser might preferably be made harder than that of the battleship; and though such a distinction has never been recognized, and may be regarded as a refinement, it may have had influence, especially in retarding the adoption of nickel in medium armour, noticed hereafter. The power of guns to destroy hard and soft armour is greatly affected by the fact that the former requires to be shattered, the latter perforated. So far as the shot holds together on impact, shattering depends on its striking energy, while perforation depends directly on the energy, but nearly inversely on the calibre of the shot and consequent size of hole to be made. Thus for many years a new type 6-inch and an old type 10-inch gun were on board the *Nettle* at Portsmouth. The energy of the latter was about double that of the former, and its shattering power was probably proportionately greater, *i.e.*, about double; but its velocity was less, and the perforating power of the two projectiles was nearly the same. Thus against Gruson's shields the old heavy gun would deliver far the heavier blow, while the new type light gun would perforate any ship's side that was open to the attack of the 10-inch gun.

As noticed above, British coast armour is made of wrought iron, and is consequently liable to some evils from which Gruson's chilled iron is free; that is to say, it is conceivable that it might be perforated, though it is made thick enough to make this unlikely. Bolts might fly under a heavy blow, and injury might be done by these and other pieces of metal, or debris forming what is termed "longridge." On the other hand, the plate upon plate or sandwich system lends itself to future alterations and additions that are impossible with Gruson's armour, which has finality stamped on it, and might become a troublesome hindrance. Every preparation is, in fact, made for the addition of extra front plates to the armour on British coast forts, which can be removed, altered, or strengthened with the least conceivable labour. The best armour now made is intermediate between hard and soft, but generally yields by perforation more than fracture. Steel armour plates, although tried from time to time, long proved brittle, and gave little promise of success. In October 1876, however, was commenced at Spezia a series of trials which undoubtedly led to the immediate adoption of steel in one or another form by the principal Powers. In these trials targets representing the proposed belts of the Italian battleships *Duilio* and *Dandolo* (then under construction) were erected. All were made of the same thickness, *i.e.*, nearly 22 inches of metal, but differed in the fact that iron and steel were used by different makers. These shields were attacked first by 10-inch, and subsequently by 17·72 inch (100-ton) guns. The lighter projectiles lodged harmlessly in the soft iron, but produced serious cracks and fractures in the steel. On the other hand, the enormous 2000-lb projectiles of the 100-ton gun passed through the wrought-iron plates very easily, while the steel plates stopped them, though at the cost of their own complete destruction. The resisting power of steel was seen to be so disproportionate to that of iron that its adoption in some form was a mere question of time. In England the liability to fracture was thought so objectionable that great efforts were made to secure toughness in some form; and the Sheffield makers, Cammell and Brown, brought forward what are termed compound or hard-faced plates, each kind consisting of a hard steel face cemented to a soft wrought-iron back or foundation. This armour possessed the advantage of a harder face than "all steel" plates of that date, combined with a tenacious back, and was adopted and largely made on the Continent; but long courses of competitive trials eventually proved that the "all steel" plates made by Schneider, and subsequently by other makers, were superior to the compound, mainly because the soft wrought-iron foundation gave insufficient support, though in one trial at Shoeburyness when fixed on granite a remarkable result was obtained.

In 1890 important competitive experiments in Russia and America brought out the value of two features of an entirely different character: first, a hard surface, and secondly, the ingredient nickel in steel. These are so important that they deserve to be dealt with separately.

The steel face of the compound plate was, as above noticed, harder than that of early "all steel," but this hardness was due to the employment of a front plate of harder steel throughout its mass than was deemed suitable for the foundation. Efforts were now made to impart excessive hardness to the actual surface or skin of a plate by the application of water-jets on a system proposed by Captain Tresidder, who found that water thus projected against hot metal came in actual contact with it, and produced a degree of hardness which was prevented in ordinary plunging by the formation of steam. About the same time Harvey in America perfected a process of carbonization applied to the front of armour plates. This could be extended to some inches in depth, and with it was associated an application of water to the face, but of a less perfect kind than on the Tresidder plan. It was found that a shot which would perforate a plate with an ordinary untreated face might be completely broken and defeated by a very hard skin. Successful resistance apparently depends on the fracture of the shot point or extreme tip on first contact. On the fracture of the tip, penetration becomes much more difficult, while the shot is still laterally unsupported, so that the latter may break outwards on the same principle as an arch may yield laterally under pressure applied to the centre. Palliser chilled shot indeed often broke on ordinary plates so completely that white radiating splashes were made by the minute particles flying across the plate face. At the date when Harvey and Tresidder plates came in steel projectiles had superseded those of chilled iron. These steel projectiles had tough bodies, with heads hardened by water or oil, and combined the penetration possessed by a hard point with considerable power to remain intact, so that steel shot would strike an ordinary steel plate at a fairly high velocity, penetrate to a considerable depth (perhaps more than a calibre), then bound back a long way towards the firing point, and yet suffer such inappreciable deformation or internal injury as to be capable of being repeatedly fired at armour, and of repeatedly behaving in the manner described.

On faces hardened by the Harvey and Tresidder processes, which soon became combined, excellent steel projectiles not only broke, but became so completely disintegrated at times that the white splash mentioned as characteristic of the defeat of chilled iron shot was seen; and a very curious device has been adopted to enable the shot to hold together, namely, a wrought-iron or steel cap applied to the shot point. It had been discovered accidentally at Shoeburyness in 1877 that a chilled shot which was defeated by a certain compound shield would perforate it when an additional plate of wrought-iron 2½ inches thick was added in front of the shield, the explanation being that the additional resistance afforded by this soft plate by no means compensated for the fact that the shot point entered easily, and was well supported and saved from fracture before it encountered the steel. Colonel (then Lieutenant) English suggested that a wrought-iron cap on the shot point might give the same result. This did not prove successful with compound plates, but when the experiment took place with very much harder, but necessarily thin, water-hardened skins in Russia in 1894, the same device of iron or steel caps was tried with success. Similar results have been obtained since in America and England, and it is probable that such caps may be used in actual war. Fig. 6 (see Plate) shows the back of a plate of Beardmore's recently attacked. A capped shot point nearly bored its way through, opening the metal in a star-shaped tear at 7. Uncapped shot were set up, and acted as punches, partially dislodging discs of plate, as seen at 2, 3, and 5. Harveyed armour was adopted in Great Britain in 1892.

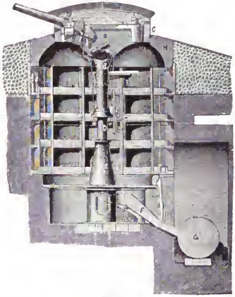


Fig. 10.

In 1890 a Schneider 10½-inch steel plate, containing nickel, behaved well at Annapolis under the attack of 6-inch and 8-inch guns, exhibiting great toughness, and nickel was introduced soon afterwards in American armour. In England considerable delay took place, because nickel plate, till thoroughly understood, appeared to be capricious in its behaviour, and the supply of armour was then being pressed forward to meet the demands arising from the increase in the British Navy. Nickel was, however, adopted in 1896. As above mentioned, nickel used with judgment imparts toughness to armour without interfering with face hardening. Fig. 7 (see Plate) shows the front of a good specimen of unhardened 6-inch Krupp nickel plate after attack by 12, 15, and 17 cm. (4·7, 5·9, and 6·7 inch) guns. A fringed lip, characteristic of soft steel, rises up round each shot hole, but no cracking is visible; the projectiles have rebounded from their holes owing to the elasticity of plate and shot. This plate is the *beau idéal* of armour for inland forts. Krupp had manufactured armour for some little time, but first became known as the inventor of a special process at the World's Fair in Chicago in 1893, where he exhibited a plate which had borne very severe attack admirably. In 1895 a series of experiments took place with Krupp process armour, in which remarkable results were obtained, the most important being that shown in Fig. 8 (see Plate), which depicts the front of a plate 11·8 inches thick after attack by three 12-inch projectiles. These have broken, leaving their heads lodged in the plate without cracking it. The highest striking velocity was 1993 feet per second. The shot weighed 712·7 ℔, and it would have perforated an iron plate 25·9 inches thick. The remarkable feature is the scale on which this success was achieved; for while a 12-inch plate may resist perforation by a 12-inch shot nearly as well as a 6-inch plate resists that of a 6-inch shot, the strain in the way of fracture greatly increases in the thicker plate, for the width of the thick plate is often not very much greater than that of the thin one. In these trials the 12-inch plate was about 6 feet wide, and the 6-inch nearly 5 feet, so that while the 6-inch shot head formed a wedge little more than one-tenth of the width of the plate attacked, the 12-inch plate was attacked with a wedge nearly one-sixth of its width. The figure indeed shows what enormous wedges are driven into the plate, and the excellence of metal bearing such a strain is apparent. At the end of 1896 the three great Sheffield armour-making firms, Brown, Cammell, and Vickers, purchased Krupp's process. Fig. 9 (see Plate) shows an admirable 6-inch plate submitted by Vickers for trial in March 1897. This entirely defeated the attack of six 6-inch projectiles striking with a velocity of about 1960 feet per second. All the armour at present made for the British Navy is practically on the Krupp process, although modifications may be introduced by each firm based on their own experience. Messrs Beardmore in Scotland have recently made armour by a process of their own, of about the same quality as Harveyed armour.

Excellent armour-piercing projectiles are made by Elswick on the American Wheeler Sterling patent, and Elswick and Firth have made large deliveries of shot on Firminy's patent. Many years ago Whitworth steel shot stood first in quality. Holtzer's subsequently became best known, and have been used so universally as to furnish a sort of standard of comparison. Krupp makes excellent projectiles, so does the firm of St Chamond. Carpenter shot in America are hardly inferior to those of Wheeler Sterling, or to a notable shot recently made by Johnson. The latter have probably obtained the greatest known penetration, but as they are generally made solid and fired with caps, comparison with others is difficult. In England Hadfields deserve special notice as having by special processes developed admirable projectiles, and especially as having made cast steel of a quality rivalling good forged steel. Lastly, the Royal Laboratory has also made excellent armour-piercing projectiles.

Before leaving the subject of the behaviour of armour under fire, one or two rough rules of thumb, which are based on calculation, may be given. The thickness of wrought iron which a projectile may perforate is about one calibre for each 1000 feet of striking velocity; that is to say, a 6-inch shot with 2000 feet velocity may perforate two calibres or 12 inches of iron, with 1500 feet it may perforate 9 inches, and so on. The equivalent thickness of the best steel plate now known is rather less than half that of wrought iron, so that a 6-inch shot will require something over 2000 feet velocity to perforate 6 inches of treated steel, while 1000 feet velocity will hardly carry it through 3 inches.

Attempts have been made to destroy armour by shells containing powder and high explosives, but hitherto it may be said that unless the projectile gets its head well

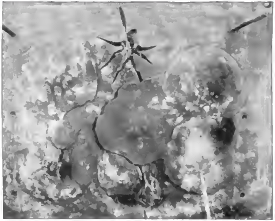


Fig. 6.

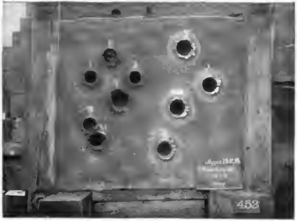


Fig. 7.

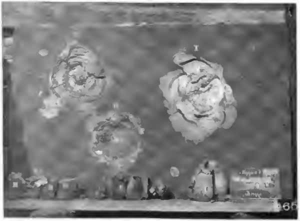


Fig. 8.

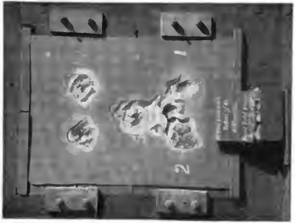


Fig. 9.

Tests of Armour Plates (see p. 672).

into the plate before explosion takes place, the effect is small. Consequently only those shells whose calibre considerably exceeds the thickness of the armour attacked can be used with good effect, and the preponderance should be greater with high explosives than with powder. In consequence of the destructive effect of shells charged with melinite and other high explosives on stone or earthworks, armoured structures have been adopted for inland defences on the Continent. These generally take the forms of cupolas and shielded mountings, which may be fixed, disappearing, or even portable. Fig. 10 shows a disappearing shielded mounting. The gun is protected by a steel armoured curved roof A, fixed on a central pillar Bd and DE, on which the whole system revolves. The gun is shown in action, the weight being held up by a counterweight G at the end of a lever Fh. The gun can be run back inside the port, and the roof lowered to rest flush with the "glacis plate" or "vorpanser" CH. When thus taken out of action the gun is hardly open to attack of any kind.

With regard to manufacture, the newest and most interesting processes depend on delicate methods of treatment, which are carefully kept secret, so that information of a general character only can be given. Wrought iron is formed from scrap worked into slabs, and piled and rolled in so many successive processes that an 8-inch plate was said to have been rolled out of a column nearly 100 feet high. Specially soft fibrous iron was used. It was considered not only that great power of drawing out, but of doing so easily was necessary, because some metal, which might draw out well slowly, might tear in preference under a blow. Steel has been used of all descriptions, from something closely resembling wrought iron to really hard metal. Molecular displacement occurs round the point of impact, and metal becomes heaped up and heated, and cracking may take place many minutes after impact. In Fig. 7 may be noticed round each point of impact a concentric circle of lighter shade than the rest of the plate, which extends gradually, and has been likened to the swelling of a black eye. Badly-made plates have been known to break spontaneously, and steel shot have done the same. Compound armour was made by running molten steel on to a white hot foundation plate of rolled wrought iron on Wilson's process, or by attaching a thin steel face plate to a wrought-iron foundation by running molten steel in between them on Ellis's process. In the Harvey process the face is carbonized by contact with carbon at a high temperature, kept up for several days, the face being finally water-hardened. There is some difficulty in bringing such plates to the exact curve required for the ship's side, because face hardening causes contortion. It is possible to flatten a plate slightly by compressing the hard face, but not to bend it further by stretching it. Until recently, armour under 5 inches thick could not be Harveyed, because contortion could not be controlled. In the Krupp process carbonization may be produced by the action of gas, but not necessarily so. Some of the stages of manufacture require much experience, so that great expense and waste of material are apt to be involved in first adopting the process, especially with thick plates. It is said that in this process metal is at times used which would be expected to prove brittle, but which, after being subjected to treatment that would be likely to render it still worse, is eventually made very tough. Up to the present it has probably owed some of its qualities to the presence of nickel. It has been said that nickel would be dispensed with, but such reports have hitherto been contradicted.

(C. O.-B.)

Armstrong, William George Armstrong, Baron (1810-1900), British inventor and founder of the Elswick manufacturing works, was born on 26th November 1810, at Newcastle-on-Tyne, and was educated at a school in Bishop Auckland. The profession which he adopted was that of a solicitor, and for a number of years he was engaged in active practice in Newcastle as a member of the firm of Donkin, Stable, & Armstrong. His sympathies, however, were always with mechanical and scientific pursuits, and several of his inventions date from a time anterior to his final abandonment of the law. In 1840 he published a paper on the electricity of effluent steam. This subject he was led to study by the experience of a colliery engineman, who noticed that he received a sharp shock on exposing one hand to a jet of steam issuing from a boiler with which his other hand was in contact, and the inquiry was followed by the invention of the "hydro-electric" machine, a powerful generator of electricity, which was thought worthy of careful investigation by Faraday. The question of the utilization of water-power had engaged his attention even earlier, and in 1838 he made his first contribution to hydraulic engineering by inventing a rotary water motor. Soon afterwards he designed a hydraulic crane, which contained the germ of all the hydraulic machinery for which he and Elswick were subsequently to become famous. This machine depended simply on the pressure of water acting directly in a cylinder on a piston, which was connected with suitable multiplying gear. In the first example, which was erected on the quay at Newcastle in 1846, the necessary pressure was obtained from the ordinary water mains of the town; but the merits and advantages of the device soon became widely appreciated, and a demand arose for the erection of cranes in positions where the pressure afforded by the mains was insufficient. Of course pressure could always be obtained by the aid of special reservoirs, but to build these was not always desirable, or even practicable. The first way in which Armstrong attempted to meet the difficulty was by the use of an air vessel, but this did not prove very satisfactory in the few cases in which it was tried. Hence, when in 1850 a hydraulic installation was required for a new ferry station at New Holland, on the Humber estuary, the absence of water mains of any kind, coupled with the prohibitive cost of a special reservoir owing to the character of the soil, impelled him to invent a fresh piece of apparatus, the "accumulator," which consists of a large cylinder containing a piston that can be loaded to give any desired pressure, the water being pumped in below it by a steam-engine or other prime mover. This simple device may be looked upon as the crown of the hydraulic system, since by its various modifications the installation of hydraulic power became possible in almost any situation. In particular, it was rendered practicable on board ship, and its application to the manipulation of heavy naval guns and other purposes on warships was not the least important of Armstrong's achievements.

The Elswick works were originally founded for the manufacture of this hydraulic machinery, but it was not long before they became the birthplace of a revolution in gunmaking; indeed, could nothing more be placed to Armstrong's credit than their establishment, his name would still be worthy of remembrance, for they have contributed enormously to the progress of the world in the mechanical arts, both of war and of peace. Modern artillery dates from about 1856, when Armstrong's first gun made its appearance. Of this weapon it may be affirmed that it embodied all the essential features which distinguish the ordnance of to-day from the cannon of the Middle Ages—it was built up of rings of metal shrunk upon an inner steel barrel; it was loaded at the breech; it was rifled; and it threw, not a round ball, but an elongated projectile with ogival head. Big guns, as Armstrong found them, were really nothing more than blocks of metal bored with a circular hole, their makers generally working on the assumption that their strength was proportionate to the thickness of the walls of the tube. But he saw that the greatest resistance to bursting was not to be obtained from a given weight of metal in this fashion, since the inner portions of the material composing a cylinder, which is subjected to high internal pressure, may be strained beyond the bursting-point before the outer ones have reached it. Hence he adopted the "shrinkage" principle of construction. Starting with a steel tube to form the barrel, he made a homogeneous cylindrical jacket by winding a bar of wrought-iron round a mandril slightly smaller than the barrel, and welding the turns together. This, when cold, was naturally too small to pass over the barrel; it could, however, be slipped on if expanded by heat, and, if it were then allowed to cool, its contraction brought about a condition of compression in the metal forming the inner layers of the gun, together with one of tension in those composing the outer ones, which theory indicated would offer the most advantageous disposition of metal as regards resistance to bursting. The guns which Armstrong constructed on this principle yielded such excellent results, both in range and accuracy, that they were adopted by the British Government in 1859, he himself being appointed Engineer of Rifled Ordnance and receiving the honour of knighthood. Great Britain thus originated a principle of gun construction which has since been universally followed, and obtained an armament superior to that possessed by any other country at that time. But while there was no doubt as to the shooting capacities of these guns, defects in the breech mechanism soon became equally patent, and in a few years caused a reversion to muzzle-loading. Armstrong resigned his position in 1863, and for seventeen years the Government's expert advisers remained faithful to the older method of loading, refusing to see the improvements which experiment and research at Elswick and elsewhere had during that period produced in the mechanism and performance of heavy guns. But at last Armstrong's results became too good to be ignored; and the official eye being no longer able to blink the fact that his long breech-loaders possessed advantages unobtainable with the obsolete type of muzzle-loaders, breech-loading guns were received back into the service in 1880. It should be mentioned that the use of steel wire for the construction of guns was also one of Armstrong's early ideas. He perceived that to coil many turns of thin wire round an inner barrel was a logical extension of the large hooped method already mentioned, and in conjunction with Brunel, the engineer, was preparing to put the plan to practical test when the discovery that it had already been patented caused him to abandon his intention for many years. This incident well illustrates the ground of his objection to the British system of patent law, which he looked upon as calculated to stifle invention and impede progress; the patentees in this case did not manage to make a practical success of their invention themselves, but the existence of prior patents was sufficient to turn him aside from a path which conducted him to valuable results, when afterwards, owing to the expiry of those patents, he was free to pursue it as he pleased.

Lord Armstrong, who was raised to the peerage in 1887, was the author of *A Visit to Egypt* (1873) and *Electric Movement in Air and Water* (1897), besides many professional papers. He died on 27th December 1900, at Rothbury, Northumberland. (H. M. R.)

Arnhem, the chief town of the province of Gelderland, Netherlands, 9 miles N. by E. of Nimeguen. Population, 31,626 in 1870, 56,812 in 1900. This increase is due to the beautiful situation of the town on the slope of the Veluwe Hills, its proximity to the fertile Betuwe district, the meeting of the Rhine and Ysel near the town, and its flourishing markets and shipping. A new Roman Catholic Church was founded in 1894; in 1880 a building to contain the archives was erected, and in 1893 an hospital. The large assembly hall (*Musis Sacrum*) was rebuilt in 1889, and the gasworks in 1892-93. A wharf for building and restoring iron steamers was constructed on the Rhine in 1889.

Arnim, Harry Karl Kurt Eduard von, COUNT (1824-1881), German diplomatist, was a member of one of the most numerous and most widely spread families of the Prussian nobility. He was born in Pomerania on the 3rd of October 1824, and brought up by his uncle Henry von Arnim, who was Prussian ambassador at Paris and foreign minister from March to June 1848, while Count Arnim of Boytzenburg, whose daughter Harry von Arnim afterwards married, was minister-president. It is noticeable that the uncle was brought before a court of justice and fined for publishing a pamphlet directed against the ministry of Manteuffel. After holding other posts in the diplomatic service Arnim was in 1864 appointed Prussian envoy, and in 1867 envoy of the North German Confederation at the Papal Court. In 1869 he proposed that the Governments should appoint representatives to be present at the Vatican Congress, a suggestion which was rejected by Bismarck, and foretold that the promulgation of papal infallibility would bring serious political difficulties. After the recall of the French troops from Rome he attempted unsuccessfully to mediate between the pope and the Italian Government. He was appointed in 1871 German commissioner to arrange the final treaty with France, a task which he carried out with such success that in 1871 he was appointed German envoy at Paris, and in 1872 received his definite appointment as ambassador, a post of the greatest difficulty and responsibility. Differences soon arose between him and Bismarck; he wished to support the Monarchical party which was trying to overthrow Thiers, while Bismarck ordered him to stand aloof from all French parties; he did not give that implicit obedience to his instructions which Bismarck required. Bismarck, however, was unable to recall him because of the great influence which he enjoyed at court and the confidence which the emperor placed in him. He was looked upon by the Conservative party, who were trying to overthrow Bismarck, as his successor, and it is said that he was closely connected with the court intrigues against the chancellor. In the beginning of 1874 he was recalled and appointed to the embassy at Constantinople, but this appointment was immediately revoked. A Vienna newspaper published some correspondence on the Vatican council including confidential despatches of Arnim's, with the object of showing that he had shown greater foresight than Bismarck. It was then found that a considerable number of papers were missing from the Paris embassy, and on 4th October Arnim was arrested on the charge of embezzling state papers. This recourse to the criminal law against a man of his rank, who had held one of the most important diplomatic posts, caused great astonishment. His defence was that the papers were not official, and he was acquitted on the charge of embezzlement but convicted of undue delay in restoring official papers and condemned to three months' imprisonment. On appeal the sentence was increased to nine months. Arnim avoided imprisonment by leaving the country, and in 1875 published anonymously a pamphlet entitled "Pro Nihilo," in which he attempted to show that the attack on him was caused by Bismarck's personal jealousy. For this he was accused of treason, insult to the emperor, and libelling Bismarck, and in his absence condemned to five years' penal servitude. From his exile in Austria he published two more pamphlets on the ecclesiastical policy of Prussia, "Der Nuntius Kommt," and "Quid faciamus nos?" He made repeated attempts, which were supported by his family, to be allowed to return to Germany in order to take his trial afresh on the charge of treason; his request had just been granted when he died on the 19th of May 1881.

In 1876 Bismarck carried an amendment to the criminal code making it an offence punishable with imprisonment or a fine up to £250 for an official of the Foreign Office to communicate to others official documents, or for an envoy to act contrary to his instructions. These clauses are commonly spoken of in Germany as the "Arnim paragraphs." (J. W. HE.)

Arnold, Sir Edwin, (1832-——), British poet, orientalist, and man of letters, was born on 10th June 1832 and educated at King's College, London, and University College, Oxford, where in 1852 he gained the Newdigate prize for a poem on Belshazzar's Feast. He spent some years in India as principal of the Government Sanscrit College, Poona, and upon his return in 1861 became connected with the *Daily Telegraph* newspaper, upon whose editorial staff he has ever since held an important position. He is nevertheless best known for his travels in India and Japan, and his endeavours to introduce Eastern thought to Europeans by a succession of works in prose and verse on Oriental subjects, both original and translated. The best known of these, *The Light of Asia*, an epical poem on the life and teaching of Buddha, entirely derived from native sources, has gone through more than sixty English and eighty American editions since its first publication in 1879. His other principal volumes of poetry are *With Sa'di in the Garden*, *The Light of the World*, *Potiphar's Wife*, *Adzuma*. In 1877, on the proclamation of Queen Victoria as Empress of India, the Companionship of the Star of India was conferred upon him; and in 1888 he was created K.C.I.E.

Arnold, Matthew (1822-1888), English poet, literary critic, and inspector of schools, was born at Laleham, near Staines, 24th December 1822. When it is said that he was the son of the famous Dr Arnold of Rugby, and that Winchester, Rugby, and Balliol College, Oxford, contributed their best towards his education, it seems superfluous to add that, in estimating Matthew Arnold and his work, training no less than original endowment has to be considered. A full academic training has its disadvantages as well as its gains. In the individual no less than in the species the history of man's development is the history of the struggle between the impulse to express original personal force and the impulse to make that force bow to the authority of custom. Where in any individual the first of these impulses is stronger than usual, a complete academic training is a gain; but where the second of these impulses is the dominant one, the effect of the academic habit upon the mind at its most sensitive and most plastic period is apt to be crippling. In regard to Matthew Arnold, it would be a bold critic of his life and his writings who should attempt to say what his work would have been if his training had been different. In his judgments on Goethe, Wordsworth, Byron, Shelley, and Hugo, it may be seen how strong was his impulse to bow to authority. On the other hand, in Arnold's ingenious reasoning away the conception of Providence to "a stream of tendency not ourselves which makes for righteousness," we see how strong was his natural impulse for taking original views. The fact that the very air Arnold breathed during the whole of the impressionable period of his life was academic is therefore a very important fact to bear in mind.

In one of his own most charming critical essays he contrasts the poetry of Homer, which consists of "natural thoughts in natural words," with the poetry of Tennyson, which consists of "distilled thoughts in distilled words." "Distilled" is one of the happiest words to be found in poetical criticism, and it may be used with equal aptitude in the criticism of life. To most people the waters of life come with all their natural qualities—sweet or bitter—undistilled. Only the ordinary conditions of civilization, common to all, flavoured the waters of life to Shakespeare, to Cervantes, to Burns, to Scott, to Dumas, and those other great creators whose minds were mirrors—broad and clear—for reflecting the rich drama of life around them. To Arnold the waters of life came distilled so carefully that the wonder is that he had any originality left. A member of the upper stratum of that "middle class" which he despised, or pretended to despise—the eldest son of one of the most accomplished as well as one of the most noble-tempered men of his time—Arnold from the moment of his birth drank the finest distilled waters that can be drunk even in these days. Perhaps, on the whole, the surprising thing is how little he suffered thereby. Indeed those who had formed an idea of Arnold's personality from their knowledge of his "culture," and especially those who had been delighted by the fastidious and feminine delicacy of his prose style, used to be quite bewildered when for the first time they met him at a dinner-table or in a friend's smoking-room. His prose was so self-conscious that what people expected to find in the writer was the Arnold as he was conceived by certain "young lions" of journalism whom he satirized—a somewhat over-cultured *petit-maître*—almost, indeed, a coxcomb of letters. On the other hand, those who had been

MATTHEW ARNOLD.
(From a photograph by Elliott and Fry, London.)

captured by his poetry expected to find a man whose sensitive organism responded nervously to every uttered word as an Æolian harp answers to the faintest breeze. What they found was a broad-shouldered, manly—almost burly—Englishman with a fine countenance, bronzed by the open air of England, wrinkled apparently by the sun, wind-worn as an English skipper's, open and frank as a fox-hunting squire's—and yet a countenance whose finely chiselled features were as high-bred and as commanding as Wellington's or Sir Charles Napier's. The voice they heard was deep-toned, fearless, rich, and frank, and yet modulated to express every *nuance* of thought, every movement of emotion and humour. In his prose essays the humour he showed was of a somewhat thin-lipped kind; in his more important poems he showed none at all. It was here, in this matter of humour, that Arnold's writings were specially misleading as to the personality of the man. Judged from his poems, it was not with a poet like the writer of "The Northern Farmer," or a poet like the writer of "Ned Bratts," that any student of poetry would have dreamed of classing him. Such a student would actually have been more likely to class him with two of his contemporaries between whom and himself there were but few points in common, the "humourless" William Morris and the "humourless" Rossetti. For, singularly enough, between him and them there was this one point of resemblance: while all three were richly endowed with humour, while all three were the very lights of the sets in which they moved, the moment they took pen in hand to write poetry they became sad. It would almost seem as if, like Rossetti, Arnold actually held that poetry was not the proper medium for humour. No wonder, then, if the absence of humour in his poetry did much to mislead the student of his work as to the real character of the man.

After a year at Winchester, Matthew Arnold entered Rugby School in 1837. He early began to write and print verses. His first publication was a Rugby prize poem, *Alaric at Rome*, in 1840. This was followed in 1843, after he had gone up to Oxford in 1840 as a scholar of Balliol, by his poem *Cromwell*, which won the Newdigate prize. In 1844 he graduated with second-class honours, and in 1845 was elected a fellow of Oriel College, where among his colleagues was A. H. Clough, his friendship with whom is commemorated in that exquisite elegy *Thyrsis*. From 1847 to 1851 he acted as private secretary to Lord Lansdowne; and in the latter year, after acting for a short time as assistant-master at Rugby, he was appointed to an Inspectership of Schools, a post which he retained until two years before his death. He married, in June 1851, the daughter of Mr Justice Wightman. Meanwhile, in 1848, appeared *The Strayed Reveller, and other Poems, by A*, a volume which gained a considerable esoteric reputation. In 1852 he published another volume under the same initial, *Empedocles on Etna*—as undramatic a poem, perhaps, as was ever written in dramatic form, but studded with lyrical beauties of a very high order. Other poems accompanied this. In 1853 Arnold published a volume under his own name. This consisted partially of poems selected from the two previous volumes. A second series of poems was published in 1855. So great was the impression made by these in academic circles that in 1857 Arnold was elected professor of poetry at Oxford, and he held the chair for ten years. In 1858 he published his classical tragedy, *Merope*. Nine years afterwards his *New Poems* were published. While he held the Oxford professorship he published several series of lectures, which gave him a high place as a scholar and critic. The essays *On Translating Homer*, published in 1861, and *On the Study of Celtic Literature*, published in 1867, were full of subtle and brilliant if not of profound criticism. So were the two series of *Essays in Criticism*, the first of which appeared in 1865, and the second, edited by Lord Coleridge, in 1888. His poetic activity almost ceased after he left the chair of poetry at Oxford. He was several times sent by Government to make inquiries into the state of education in France, Germany, Holland, and other countries; and his reports, with their thorough-going and searching criticism of Continental methods, as contrasted with English methods, showed how conscientiously he had devoted some of his best energies to the work.[1] In 1883

---

[1] The following appreciation of Arnold's educational work is kindly contributed by Sir Joshua Fitch, one of his colleagues in the Education Office:—

The fame of Matthew Arnold as a poet and a literary critic has somewhat overshadowed the fact that he was during thirty-five years of his life—from 1851 to 1886—employed in the Education Department as one of H. M. Inspectors of Schools. His literary work was achieved in such intervals of leisure as could be spared from the public service. At the time of his appointment the Government, by arrangement with the religious bodies, antrusted the inspection of schools connected with the Church of England to clergymen, and agreed also to send Roman Catholic inspectors to schools managed by members of that communion. Other schools—those of the British and Foreign Society, the Wesleyans, and undenominational schools generally—were inspected by laymen, of whom Arnold was one. There were only three or four of these officers at first, and their districts were necessarily large. It is to the experience gained in intercourse with Nonconformist school managers that we may attribute the curiously intimate knowledge of religious sects which furnished the material for some of his keen though good-humoured sarcasms. The Education Act of 1870, which simplified the administrative system, abolished denominational inspection, and thus greatly reduced the area assigned to a single inspector. Arnold took charge of the district of Westminster, and remained in that office until his resignation, taking also an occasional share in the inspection of training colleges for teachers, and in conferences at the central office. His letters, *passim*, show that some of the routine which devolved upon him was distasteful, and that he was glad to entrust to a skilled assistant much of the duty of individual examination and the making up of schedules and returns. But the influence he exerted on schools, on the Department, and on the primary education of the whole country, was indirectly far greater than is generally supposed. His annual reports, of which more than twenty were collected into a volume by his friend and official chief, Sir Francis (afterwards Lord) Sandford, attracted, by reason of their freshness of style and thought, much more of public attention than is usually accorded to Blue-book literature; and his high aims, and his sympathetic appreciation of the efforts and difficulties of the teachers, had a remarkable effect in raising the tone of elementary education, and in indicating the way to improvement. In particular, he insisted on the formative elements of school education, on literature and the "humanities," as distinguished from the collection of scraps of information and "useful knowledge"; and he sought to impress all the young teachers with the necessity of broader mental cultivation than was absolutely required to obtain the Government certificate. In his reports also he dwelt often and forcibly on the place which the study of the Bible, not the distinctive formularies of the churches, ought to hold in English schools. He urged that besides the religious and moral purpose of Scriptural teaching, it had a literary value of its own, and was the best instrument in the hands even of the elementary teacher for uplifting the soul and refining and enlarging the thoughts of young children.

On three occasions Arnold was asked to assist the Government by making special inquiries into the state of education in foreign countries. These duties were especially welcome to him, serving as they did as a relief from the monotony of school inspection at home, and as opportunities for taking a wider survey of the whole subject of education, and for expressing his views on principles and national aims as well as administrative details. In 1859 he prepared for the Duke of Newcastle's Commission a report which was afterwards reprinted in a volume entitled *Popular Education in France, with Notes of that of Holland and Switzerland*. In 1865 he was again employed as assistant-commissioner by the Schools Inquiry Commission under Lord Taunton; and his report on this subject was subsequently reprinted under the title *Schools and Universities on the Continent*. Twenty years later he was sent by the Education Department to make special inquiries on certain specified points—*e.g.* free education, the status and training of teachers, and compulsory attendance at schools. The result of this investigation appeared as a parliamentary paper in 1886. He also contributed the chapter on "Schools" to the second volume of Mr Humphry Ward's *Reign of Queen Victoria*.

All these reports form substantial contributions to the history and literature of education in the Victorian age. They have been quoted a pension of £250 was conferred on him in recognition of his literary merits. In the same year he went to the United States on a lecturing tour, and again in 1886, his subjects being "Emerson" and the "Principles and Value of Numbers." The success of these lectures, though they were admirable in matter and form, was marred by the lecturer's lack of experience in delivery. It is sufficient, further, to say that *Culture and Anarchy* appeared in 1869; *St Paul and Protestantism*, 1870; *Friendship's Garland*, 1871; *Literature and Dogma*, 1873; *God and the Bible*, 1875; *Last Essays on Church and Rebellion*, 1877; *Mixed Essays*, 1879; *Irish Essays*, 1882; and *Discourses on America*, 1885. Such essays as the first of these, embodying as they did Arnold's views of theological and polemical subjects, attracted much attention at the time of their publication, owing to the state of the intellectual atmosphere at the moment; but it is doubtful, perhaps, whether they will be greatly considered in the near future. Many severe things have been said, and will be said, concerning the inadequacy of poets like Coleridge and Wordsworth when confronting subjects of a theological or philosophical kind. Wordsworth's High Church Pantheism and Coleridge's disquisitions on the Logos seem farther removed from the speculations of to-day than do the dreams of Lucretius. But these two great writers lived before the days of modern science. Arnold, living only a few years later, came at a transition period when the winds of tyrannous knowledge had blown off the protecting roof that had covered the centuries before, but when time and much labour were needed to build another roof of new materials—a period when it was impossible for the poet to enjoy either the quietism of High Church Pantheism in which Wordsworth had basked, or the sheltering protection of German metaphysics under which Coleridge had preached—a period, nevertheless, when the wonderful revelations of science were still too raw, too cold and hard, to satisfy the yearnings of the poetic soul. Objectionable as Arnold's rationalizing criticism was to contemporary orthodoxy, and questionable as was his equipment in point of theological learning, his spirituality of outlook and ethical purpose were not to be denied. Yet it is not Arnold's views that have become current coin so much as his literary phrases—his craving for "culture" and "sweetness and light," his contempt for "the dissidence of Dissent and the Protestantism of the Protestant religion," his "stream of tendency not ourselves making for righteousness," his classification of "Philistines and barbarians"—and so forth. His death, at Liverpool, of heart failure, 15th April 1888, was sudden and quite unexpected.

Arnold was a prominent figure in that great galaxy of Victorian poets who were working simultaneously—Tennyson, Browning, Rossetti, William Morris and Mr Swinburne—poets between whom there was at least this connecting link, that the quest of all of them was the old-fashioned poetical quest of the beautiful. Beauty was their watchword, as it had been the watchword of their immediate predecessors—Wordsworth, Coleridge, Keats, Shelley, and Byron. That this group of early 19th century poets might be divided into two—those whose primary quest was physical beauty, and those whose primary quest was moral beauty—is no doubt true. Still, in so far as beauty was their quest they were all akin. And so with the Victorian group to which Arnold belonged. As to the position which he takes among them opinions must necessarily vary. On the whole, our opinion is that his place in the group will be below all the others. The question as to whether he was primarily a poet or a *prosateur* has been often asked. If we were to try to answer that question here, we should have to examine his poetry in detail—we should have to inquire whether his primary impulse of expression was to seize upon the innate suggestive power of words, or whether his primary impulse was to rely upon the logical power of the sentence. In nobility of temper, in clearness of statement, and especially in descriptive power, he is beyond praise. But intellect, judgment, culture, and study of great poets may do much towards enabling a prose-writer to write what must needs be called good poetry. What they cannot enable him to do is to produce those magical effects which poets of the rarer kind can achieve by seizing that mysterious, suggestive power of words which is far beyond all mere statement. Notwithstanding the exquisite work that Arnold has left behind him, some critics have come to the conclusion that his primary impulse in expression was that of the poetically-minded *prosateur* rather than that of the born poet. And this has been said by some who nevertheless deeply admire poems like "The Scholar Gypsy," "Thyrsis," "The Forsaken Merman," "Dover Beach," "Heine's Grave," "Rugby Chapel," "The Grande Chartreuse," "Sohrab and Rustum," "The Sick King in Bokhara," "Tristram and Iseult," &c. We need not go nearly so far as that. But it would seem that a man may show all the endowments of a poet save one, and that one the most essential—the instinctive mastery over metrical effects.

In all literary expression there are two kinds of emphasis, the emphasis of sound and the emphasis of sense. Indeed the difference between those who have and those who have not the true rhythmic instinct is that, while the former have the innate faculty of making the emphasis of sound and the emphasis of sense meet and strengthen each other, the latter are without that faculty. But so imperfect is the human mind that it can rarely apprehend or grasp simultaneously these two kinds of emphasis. While to the born *prosateur* the emphasis of sense comes first, and refuses to be more than partially conditioned by the emphasis of sound, to the born poet the emphasis of sound comes first, and sometimes will, even as in the case of Shelley, revolt against the tyranny of the emphasis of sense. Perhaps the very origin of the old quantitative metres was the desire to make these two kinds of emphasis meet in the same syllable. In manipulating their quantitative metrical system the Greeks had facilities for bringing one kind of emphasis into harmony with the other such as are unknown to writers in accentuated metres. This accounts for the measureless superiority of Greek poetry in verbal melody as well as in general harmonic scheme to all the poetry of the modern world. In writers so diverse in many ways as Homer, Æschylus, Sophocles, Pindar, Sappho, the harmony between the emphasis of sound and the emphasis of sense is so complete that each of these kinds of emphasis seems always begetting, yet always born of the other. When in Europe the quantitative measures were superseded by the accentuated measures a reminiscence was naturally and inevitably left behind of the old system; and the result has been, in the English

---

often, and have exercised marked influence on subsequent changes and controversies. One great purpose underlies them all. It is to bring home to the English people a conviction that education ought to be a national concern, that it should not be left entirely to local, or private, or irresponsible initiative, that the watchful jealousy so long shown by Liberals, and especially by Nonconformists, in regard to State action was a grave practical mistake, and that in an enlightened democracy, animated by a progressive spirit and noble and generous ideals, it was the part of wisdom to invoke the collective power of the State to give effect to those ideals. To this theme he constantly recurred in his essays, articles, and official reports. "*Porro unum est necessarium.* One thing is needful; organize your secondary education." This is an object not yet fully attained; but the influence of his stimulating appeals to the intelligence and conscience of his countrymen, and the practical value of many of his detailed suggestions, are likely to be more and more fully recognized.

language at least, that no really great line can be written in which the emphasis of accent, the emphasis of quantity, and the emphasis of sense, do not meet on the same syllable. Whenever this junction does not take place the weaker line, or lines, are always introduced, not for make-shift purposes, but for variety, as in the finest lines of Milton and Wordsworth. Wordsworth no doubt seems to have had a theory that the accent of certain words, such as "without," "within," &c., could be disturbed in an iambic line; but in his best work he does not act upon his theory, and endeavours most successfully to make the emphasis of accent, of quantity, and of sense meet. It might not be well for a poem to contain an entire sequence of such perfect lines as

> "I thought of Chatterton, the marvellous boy,"

or

> "Thy soul was like a star and dwelt apart,"

for then the metricist's art would declare itself too loudly and weaken the imaginative strength of the picture. But such lines should no doubt form the basis of the poem, and weaker lines—lines in which there is no such combination of the three kinds of emphasis—should be sparingly used, and never used for make-shift purposes. Now, neither by instinct nor by critical study was Arnold ever able to apprehend this law of prosody. If he does write a line of the first order, metrically speaking, he seems to do so by accident. Such weak lines as these are constantly occurring—

> "The poet, to whose mighty heart
> Heaven doth a quicker pulse impart,
> Subdues that energy to scan
> Not his own course, but that of man."

Much has been said about what is called the "Greek temper" of Matthew Arnold's muse. A good deal depends upon what is meant by the Hellenic spirit. But if the Greek temper expresses itself, as is generally supposed, in the sweet acceptance and melodious utterance of the beauty of the world as it is, accepting that beauty without inquiring as to what it means and as to whither it goes, it is difficult to see where in Arnold's poetry this temper declares itself. Surely it is not in *Empedocles on Etna*, and surely it is not in *Merope*. If there is a poem of his in which one would expect to find the joyous acceptance of life apart from questionings about the civilization in which the poet finds himself environed (its hopes, its fears, its aspirations, and its failures)—such questionings, in short, as were for ever vexing Arnold's soul—it would be in "The Scholar Gypsy," a poem in which the poet tries to throw himself into the mood of a "Romany Rye." The great attraction of the gypsies to Englishmen of a certain temperament is that they alone seem to feel the joyous acceptance of life which is supposed to be specially Greek. Hence it would have been but reasonable to look, if anywhere, for the expression of Arnold's Greek temper in a poem which sets out to describe the feelings of the student who, according to Glanville's story, left Oxford to wander over England with the Romanies. But instead of this we get the old fretting about the unsatisfactoriness of modern civilization. Glanville's Oxford student, whose story is glanced at now and again in the poem, flits about in the scenery like a cloud-shadow on the grass; but the way in which Arnold contrives to avoid giving us the faintest idea either dramatic or pictorial of the student about whom he talks so much, and about the gypsies with whom the student lived, is one of the most singular feats in poetry. The reflections which come to a young Oxonian lying on the grass and longing to escape life's fitful fever without shuffling off this mortal coil are, no doubt, beautiful reflections beautifully expressed, but the temper they show is the very opposite of the Greek. To say this is not in the least to disparage Arnold. "A man is more like the age in which he lives," says the Chinese aphorism, "than he is like his own father and mother," and Arnold's polemical writings alone are sufficient to show that the waters of life he drank were from fountains distilled, seven times distilled, at the topmost slope of 19th-century civilization. Mr George Meredith's "Old Chartist" exhibits far more of the temper of acceptance than does any poem by Matthew Arnold.

His most famous critical dictum is that poetry is a "criticism of life." What he seems to have meant is that poetry is the crowning fruit of a criticism of life; that just as the poet's metrical effects are and must be the result of a thousand semi-conscious generalizations upon the laws of cause and effect in metric art, so the beautiful things he says about life and the beautiful pictures he paints of life are the result of his generalizations upon life as he passes through it, and consequently that the value of his poetry consists in the beauty and the truth of his generalizations. But this is saying no more than is said in the line—

> "Rien n'est beau que le vrai ; le vrai seul est aimable"—

or in the still more famous lines—

> "'Beauty is truth, truth beauty,'—that is all
> Ye know on earth, and all ye need to know."

To suppose that Arnold confounded the poet with the writer of *pensées* would be absurd. Yet, having decided that poetry consists of generalizations on human life, in reading poetry he kept on the watch for those generalizations, and at last seemed to think that the less and not the more they are hidden behind the dramatic action, and the more unmistakably they are intruded as generalizations, the better. For instance, in one of his essays he quotes those lines from the "Chanson de Roland" of Turoldus, where Roland, mortally wounded, lays himself down under a pine-tree with his face turned towards Spain and the enemy, and begins to "call many things to remembrance; all the lands which his valour conquered, and pleasant France, and the men of his lineage, and Charlemagne, his liege lord, who nourished him"—

> "De plusurs choses à remembrer li prist,
> De tantes teres cume li bers cunquist,
> De dulce France, des humes de sun lign,
> De Carlemagne sun seignor ki l'nurrit."

"That," says Arnold, "is primitive work, I repeat, with an undeniable poetic quality of its own. It deserves much praise, and such praise is sufficient for it." Then he contrasts it with a famous passage in Homer—that same passage which has been quoted in the *Encyclopædia Britannica* (see Art. POETRY, vol. xix.) for the very opposite purpose to that of Arnold's—quoted indeed to show how the epic poet, leaving the dramatic action to act as chorus, weakens the ἀπάτη of the picture—the passage in the *Iliad* (iii. 243-4) where the poet, after Helen's pathetic mention of her brother's, comments on the causes of their absence, "criticizes life" and generalizes upon the impotence of human intelligence, the impotence even of human love, to pierce the darkness in which the web of human fate is woven. He appends Dr Hawtrey's translation:—

> Ὣς φάτο· τοὺς δ' ἤδη κάτεχεν φυσίζοος αἶα
> ἐν Λακεδαίμονι αὖθι, φίλῃ ἐν πατρίδι γαίῃ.

> "So said she; they long since in Earth's soft arms were reposing
> There, in their own dear land, their fatherland, Lacedæmon."

"We are here," says Arnold, "in another world, another order of poetry altogether; here is rightly due such supreme praise as that which M. Vitel gives to the *Chanson de Roland*. If our words are to have any meaning, if our judgments are to have any solidity, we must not heap that supreme praise upon poetry of an order immeasurably inferior." He does not see that the two passages cannot properly be compared at all. In the one case the poet gives us a dramatic picture; in the other, a comment on a dramatic picture.

Perhaps, indeed, the place Arnold held and still holds as a critic is due more to his exquisite felicity in expressing his views than to the penetration of his criticism. Nothing can exceed the easy grace of his prose at the best. It is conversational and yet absolutely exact in the structure of the sentences; and in spite of every vagary, his distinguishing note is urbanity. Keen-edged as his satire could be, his writing for the most part is as urbane as Addison's own. His influence on contemporary criticism and contemporary ideals was considerable, and generally wholesome. His insistence on the necessity of looking at "the thing in itself," and the need for acquainting oneself with "the best that has been thought and said in the world," gave a new stimulus alike to originality and industry in criticism; and in his own selection of subjects—such as *Joubert*, or the *de Guerins*—he opened a new world to a larger class of the better sort of readers, exercising in this respect an awakening influence in his own time akin to that of Walter Pater a few years afterwards. The comparison with Pater might indeed be pressed further, and yet too far. Both were essentially products of Oxford. But Arnold, whose description of that "home of lost causes, and forsaken beliefs, and unpopular names, and impossible loyalties," is in itself almost a poem, had a classical austerity in his style that savoured more intimately of Oxford tradition, and an ethical earnestness even in his most flippant moments which kept him notably aloof from the more sensuous school of æsthetics.

(T. W.-D.)

Arnstadt, a town and watering-place of Germany, in the principality of Schwarzburg-Sondershausen, 14 miles by rail S.S.W. from Erfurt, on the river Gera. The church of Our Lady was restored in 1884-86. Its manufactures embrace gloves, shoes, iron safes, confectionery, and especially beer and market-gardening. Arnstadt possesses an industrial school, and is much frequented in summer for its saline and other baths. It dates back to the 8th century. Population (1885), 11,537; (1895), 13,595; (1900), 14,413.

Arques, a town and railway station, arrondissement of St Omer, department of Pas-de-Calais, France, 37 miles in direct line N.W. of Arras. Near Arques, on the Canal de Neuffossés, is the Ascenseur des Fontinettes, a great hydraulic lift, completed in 1888, by which canal boats are enabled to avoid the series of locks constructed on the slope of the Fontinettes hill, to connect the Neuffossés with the Aa, at a difference of level of about 40 feet. Population, (1881), 2105; (1891), 1972; (1896), 2216, (comm.) 4355.

Arrah, a town of British India, headquarters of Shahabad district, in the Patna division of Bengal, situated on a navigable canal connecting the river Sone with the Ganges. It is a station on the East Indian railway, 368 miles from Calcutta. In 1891 the population was 46,905. It has a high school with over 400 pupils. Arrah is famous for an incident in the Mutiny, when a dozen Englishmen, with 50 Sikhs, defended an ordinary house against an army of many thousand insurgents. A British regiment, despatched to their assistance from Dinapur, was disastrously repulsed; but they were ultimately relieved, after eight days' continuous fighting, by a small force under Major (Sir Vincent) Eyre.

Arran, an island of Buteshire, Scotland, situated in the Firth of Clyde. The area is 165 square miles. Agriculture and the entertainment of summer visitors are the principal industries, and herrings, haddocks, whitings, and lobsters are fished; in 1898 there were 39 boats in the island, manned by seventy-three fishermen, and the value of the catch was £1220. There is an extensive steamer service connecting with the Caledonian and Glasgow and South-Western railways. Many improvements have been carried out in the principal villages, and Lamlash, in particular, has been largely extended. Population (1901), 4779.

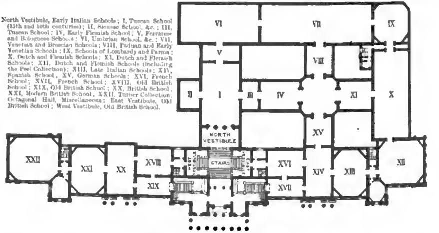
Arras, chief town of department Pas-de-Calais, France, 109 miles N.N.E. of Paris, on railway from Paris to Dunkirk and Boulogne. Amongst public buildings to be noted are the restored Hôtel de Ville, the Hôpital St Jean, and the railway station. The last-named stands at one end of a fine thoroughfare, in the new quarter formed since the demolition of the fortifications. There are new boulevards, and statues of Vauban and of the Abbé Halluin (d. 1895). The manufacture of oils, especially poppy oil, and artistic and other metallurgical work, are now the leading industries, while textile manufactures are represented chiefly by hosiery. Population (1876), 21,689, (comm.) 21,689; (1886), 21,492; (1896), 20,599, (comm.) 21,086; (1901), 25,813.

Arrasà. See ERITREA.

Art Galleries.—An art gallery epitomizes so many phases of human thought and imagination that it connotes much more than a mere collection of paintings. In its technical and æsthetic aspect the gallery shows the treatment of colour, form, and composition. In its historical aspect we find the true portraits of great men of the past; we can observe their habits of life, their manners, their dress, the architecture of their times, and the religious worship of the period in which they lived. Regarded collectively, the art of a country epitomizes the whole development of the people that produced it. Most important of all is the emotional aspect of painting, which must enter less or more into every picture worthy of notice. To take examples from the British National Gallery: Pathos in its most intense degree will be found in Francia's "Pietà"; dignity in Velasquez' portrait of Admiral Pareja; homeliness in Van Eyck's portrait of Jan Arnolfini and his wife; the interpretation of the varying moods of nature in the work of Turner or Hobbema; nothing can be more devotional than the canvases of Bellini or his Umbrian contemporaries. So also the ruling sentiments of mankind—mysticism, drama, and imagination are the key-notes of other great conceptions of the artist. All this may be at the command of those who visit the art gallery; but without patience, care, and study the higher meaning will be lost to the spectator. The picture which "tells its own story" is often the least didactic, for it has no inner or deeper lesson to reveal; it gives no stimulus or training to the eye, quick as that organ may be—*segnius irritant animos*—to translate sight into thought. In brief, the painter asks that his ἦθος may be shared as much as possible by the man who looks at the painting—the art above all others in which it is most needful to share the master's spirit if his work is to be fully appreciated. So, too, the art gallery, recalling the gentler associations of the past amidst surroundings of harmonious beauty and its attendant sense of comfort, is essentially a place of rest for the mind and eye. In the more famous galleries where the wealth of paintings allows a grouping of pictures according to their respective schools, one may choose the country, the epoch, the style, or even the emotion best suited to one's taste. According to this theory, though imperfectly realized owing to the paucity of examples, the philosophic influence of art galleries is becoming more widely extended; and in its further development will be found an ever-growing source of interest, instruction, and scholarship to the community. The most suitable method of describing art galleries is to classify them by their types and contents, rather than by the various countries to which they belong. Thus the great representative galleries of the world which possess works of every school are grouped together, followed by State galleries which are not remarkable for more than one school of national art. Municipal galleries are divided into those which have general collections, and those which are notable for special collections. Churches which have good paintings, together with those which are now secularized, are treated separately; while the collections in the Vatican and private houses are described together. The remaining galleries, such as the Salon or the Royal Academy, are periodical or commercial in character, and are important in the development of modern art.

State galleries of international schools.

The collections most worthy of attention are the State galleries representative of international schools. Their number is restricted, not more than a dozen being in the very first rank. Among these the British National Gallery holds a high place. Though the collection is small and modern, having been founded in 1824 by the acquisition of the Angerstein pictures, it is among the most representative of State galleries. Its accessions are governed by the parliamentary grant of £5000 to £10,000 a year, a sum which has occasionally been enlarged to permit special purchases. Thus, in 1871, the Peel collection of seventy-seven pictures was bought for £75,000, and in 1885 the Ansidei Madonna (Raffaelle) and Van Dyck's portrait of Charles I. were bought, the one for £70,000 and the other for £17,500. In 1890 the Government gave £25,000 to meet a gift of £30,000 made by three gentlemen to acquire three portraits by Moroni, Velasquez, and Holbein. The most important gifts were the Vernon gift in 1847, the Turner bequest in 1856, and the Wynne-Ellis legacy in 1876. The gallery contains very few poor works, and all schools are well represented with the sole exception of the French school. This, however, can be amply studied at Hertford House, which, besides Dutch, Spanish, and British pictures of the highest value, contains twenty examples of Greuze, fifteen by Pater, nineteen by Boucher, eleven by Watteau, and fifteen by Meissonier. The Royal Gallery at Berlin (Old Museum), like the British National Gallery, is remarkable for its variety of schools and painters, and for the select type of pictures shown. During the last twenty-five years of the 19th century, the development of this collection was even more striking than that of the English gallery. Italian and Dutch examples are specially numerous, though every school but the British (here as elsewhere) is really well seen. The purchase grant is considerable, and is well applied. Two other German capitals have collections of international importance — Dresden and Munich. The former is famous for the Sistine Madonna by Raffaelle, a work of such supreme excellence that there is a tendency to overlook other Italian pictures of celebrity by Titian, Giorgione, and Correggio. Munich (Old Pinakothek) has examples of all the best masters, the South German school being particularly noticeable. The arrangement is good, and the methods of exhibition make this one of the most pleasant galleries on the Continent. Vienna has the Imperial Gallery, a collection which in point of number cannot be considered large, as there are not more than 1700 pictures. This, however, is in itself a safeguard, like the wise provision enabling the English authorities to dispose of pictures "unfit for the collection, or not required" (19 and 20 Vict. c. 29). It avoids the undue multiplication of canvases, and the overcrowding so noticeable in many Italian galleries where first-rate pictures hang too high to be examined. Thus the Viennese gallery, besides the intrinsic value of its pictures (Albert Dürer's chief work is there), is admirably adapted for study. The best gallery in Russia (St. Petersburg, Hermitage) was made entirely by royal efforts, having been founded by Peter the Great, and much enlarged by the Empress Catharine. It contains the collections of Crozat, Brühl, and Walpole. There are about 1800 works, the schools of Flanders and Italy being of signal merit; and there are at least thirty-five genuine examples by Rembrandt. The French collection (Louvre Palace, Paris) is one of the most important of all. In 1880 it was undoubtedly the first gallery in Europe, but its supremacy has since been menaced by other establishments where acquisitions are



North Vestibule, Early Italian Schools; I, Tuscan School (15th and 16th centuries); II, Sienese School, &c.; III, Tuscan School; IV, Early Flemish School; V, Ferrarese and Bolognese Schools; VI, Umbrian School, &c.; VII, Venetian and Brescian Schools; VIII, Paduan and Early Venetian Schools; IX, Schools of Lombardy and Parma; X, Dutch and Flemish Schools; XI, Dutch and Flemish Schools; XII, Dutch and Flemish Schools (including the Peel Collection); XIII, Late Italian Schools; XIV, Spanish School; XV, German Schools; XVI, French School; XVII, French School; XVIII, Old British School; XIX, Old British School; XX, British School; XXI, Modern British School; XXII, Turner Collection; Octagonal Hall, Miscellaneous; East Vestibule, Old British School; West Vestibule, Old British School.

FIG. 1.—Plan of the National Gallery, London.

made more frequently and with greater care, and where the system of classification is such that the value of the pictures is enhanced rather than diminished by their display. In 1900 it was partly rearranged with great effect. The feature of the Louvre is the Salon Carré, a room in which the supposed finest canvases in the collection are kept together, pictures of world-wide fame, representing all schools. It is now generally accepted that this system of selection not only lowers the standard of individual schools elsewhere by withdrawing their best pictures, but does not add to the æsthetic or educational value of the masterpieces themselves. In Florence the Tribuna of the Uffizi gallery is a similar case in point, while in London the danger that such a central gallery should be made within the national collection passed away thirty years ago. Probably the two most widely known pictures in the Louvre are Watteau's second "Embarquement pour Cythère" and the "Mona Lisa," a portrait by Leonardo da Vinci, but each school has many unique examples. The original drawings should be noted, being of equal importance to the collection preserved at the British Museum. The last collection to be mentioned under this heading is that known as the Royal Galleries in Florence, housed in the Pitti and Uffizi palaces. In some ways this collection does not represent general painting sufficiently to justify its inclusion with the galleries of Berlin, Paris, and London. On the other hand, the great number of Italian pictures of vital importance to the history of international art makes this one of the finest existing collections. The two great palaces, dating from the 15th and 16th centuries, are joined together and contain the Medici pictures. They form the largest gallery in the world, and though many of the rooms are small and badly lighted, and although many paintings have suffered from thoughtless restoration, there is a charm and attraction which certainly make them the most popular galleries in Europe. The Pitti has ten Raffaelles, and excellent examples of Andrea del Sarto, Giorgione, and Perugino. The Uffizi is more representative of non-Italian schools, but is best known for its works by Botticelli, Leonardo da Vinci, Michael Angelo, and Sodoma, the schools of Tuscany and Umbria forming the bulk of both collections. Admission to the galleries is by payment, and the small income derived from this source (in 1890 all the galleries and museums in Florence only received £4000) is devoted to maintaining and enlarging the collections.

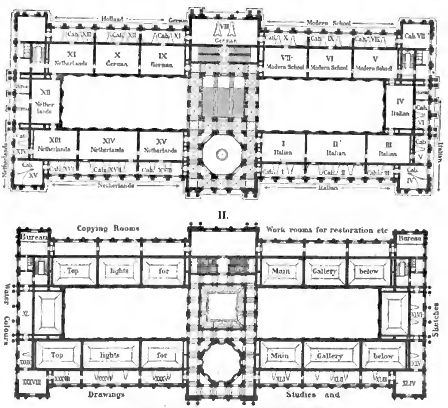


FIG. 2.—Plan of the first and second floors of the Imperial Gallery, Vienna.

As to the ground plans of the National Gallery, London (Fig. 1), and of the Imperial Gallery at Vienna (Fig. 2), it will be observed that while the former has the advantage of uniform top-light, the new galleries at Vienna possess the most ample facilities for minute classification, small rooms or "cabinets" opening from each large room. Special rooms are also provided for drawings and water-colours, while special ranges of rooms are used by copyists and those responsible for the repair and preservation of the pictures.

State galleries of national schools.

Though not so comprehensive as the great collections just described, the State galleries showing national schools of painting and little else are of striking interest. In England the National Gallery of British Art (known as the Tate Gallery) contains British pictures. The corresponding collection of modern French art is at Paris (Luxembourg Palace), Berlin, Rome, Dresden, Vienna, and Madrid having analogous galleries. The Victoria and Albert Museum has also numerous British pictures, especially in water-colour, and the National Portrait Gallery, founded in 1856, and since 1896 housed in its permanent home, is instructive in this connexion, though many of its pictures are the work of foreign artists. The national collections at Dublin and Edinburgh may be mentioned here, though most schools are represented. Brussels and Antwerp are remarkable for fine examples of Flemish art—Matsys, Memlinc, and Van Eyck of the primitive schools, Rubens and Van Dyck of the later period. The collections at Amsterdam (Ryks Museum) and the Hague (Mauritshuis) are a revelation to those who have only studied Rembrandt, Franz Hals, Van der Helst, and other Dutch portrait painters outside Holland; and in the former gallery especially, the pictures are arranged in a manner showing them to the best advantage. The Museo del Prado is even more noteworthy, for the fifty examples of Velasquez (outrivalling the Italian pictures, important as they are) make a visit to Madrid imperative to those who wish to realize the achievements of Spanish art. Christiania, Stockholm, and Copenhagen have large collections of Scandinavian art, and the cities of Budapest and Bâle have galleries of some importance. In Italy the State maintains twelve collections, mainly devoted to pictorial art. Of these the best are situated at Bologna, Lucca, Parma, Venice, Modena, Turin, and Milan. In each case the local school of painting is fully represented. In Rome the Corsini and Borghese Galleries, the latter being the most catholic in the city, contain superb examples, some of them accepted masterpieces of Italian art; there are also good foreign pictures, but their number is limited. The Accademia at Florence should also be noted as the most important State gallery of early Italian art. The central Italian Renaissance can be more adequately studied here than in the Pitti. The "Primavera" of Botticelli, and the "Last Judgment" by Fra Angelico are perhaps the best known works. The large statue of David by Michael Angelo is also in this gallery, which, on the whole, is one of the most remarkable in Italy. Speaking broadly, these national galleries scattered throughout the country are not well arranged or classified; and though some are kept in fine old buildings, beautiful in themselves, the lighting is often indifferent, and it is with difficulty that the pictures can be seen. In nearly every case admission fees are charged every day, festivals and Sundays excepted; few pictures are bought, acquisitions being chiefly made by removing pictures from churches.

Municipal galleries of special schools.

Many towns own collections of well-merited repute. In Italy such galleries are common, and among them may be noted Siena, with Sodoma and his school; Venice with Tintoretto (Doge's Palace); Genoa, with the great palaces Balbi and Rosso; Vicenza (Montagna and school), Ferrara (Dosso and school), Bergamo and Milan (north Italian schools). Other civic collections of Italian art are maintained at Verona, Pisa, Rome, Perugia, and Padua. In Holland, Haarlem, Leyden, Rotterdam, and the Hague have galleries supplemental to those of the State, and are remarkable in showing the brilliance of artists like Grebber, De Bray, and Ravesteyn, who are usually ignored. Birmingham and Manchester have good examples of modern British art. Moscow (Tretiakoff collection) has modern Russian pictures, and contemporary German and French work will be found in all the galleries of these two countries included in the municipal group. Collections of French work are found at Amiens, Rouen, Nancy, Tours, Lemans, and Angers, but large as these civic collections are, sometimes containing six and eight hundred canvases, few of their pictures are really good, many being the enormous patriotic canvases marked "Don de l'Etat," which do not confer distinction on the galleries. Cologne has the central collection of the early Rhenish school; Nuremberg is remarkable for early German work (Wohlgemut, &c.). Stuttgart, Cassel (Dutch), and Hamburg (with a considerable number of British pictures) are also noteworthy, together with Brunswick, Hanover, Augsburg, Darmstadt, and Düsseldorf where German and Dutch art preponderate. Seville is famous for twenty-five examples of Murillo, and there are old Spanish paintings at Valencia, Cordova, and Cadiz.

Municipal galleries of general schools.

In Great Britain the best of the municipal galleries of general schools are at Liverpool (early Flemish and British), and at Glasgow (Scottish painters, Rembrandt, Van der Goes, and Venetian schools). In France there are very large galleries at Tours, Montpellier, Lyons (Perugino, Rubens), Dijon, and Grenoble (Italian), Valenciennes (Watteau and school), while Rennes, Lille, and Marseilles have first-rate collections. Nantes, Orleans, Besançon, Cherbourg, and Caen have also many paintings, French for the most part, but with occasional foreign pictures of real importance, presented by the State during the Napoleonic conquests, and not returned on the declaration of peace as were the works of art amassed in Paris. Some of the American collections, though still in their early stages of development, have very good pictures. At Boston (Museum of Fine Arts) all schools are represented, so too at the Metropolitan Museum of Art in New York, which is strong in Italian and Dutch works. Modern French and Flemish art is a feature of the Academy at Philadelphia, at the Lenox Library (New York), and at Chicago, where there are good examples of Millet, Constable, and Rembrandt. The Corcoran bequest at Washington is of indifferent worth. The best civic collection in Germany of this class is the Städel Institute at Frankfort (Van Eyck, Christus, early Flemish and Italian).

Churches.

As the great bulk of religious painting was executed for church decoration, there are still numberless churches which may be considered picture galleries. Thus at Antwerp Cathedral the Rubens paintings are remarkable; at Ghent, Van Eyck; at Bruges (hospital of St John), Memlinc; at Pisa, the Campo Santo (early Tuscan schools); at Sant' Apollinare, Ravenna, primitive Italo-Byzantine mosaics; at Siena, Pinturrichio. Examples could be multiplied indefinitely—in Italy alone there are 80,000 churches and chapels, in all of which pictorial art has been employed. In Italy, besides the church "galleries" still used for religious services, there are some which have been secularized and are now used as museums, *e.g.*, Certosa at Pavia, and San Vitale at Ravenna (mosaics); at Florence, the Scalzo (Andrea del Sarto); San Marco (Fra Angelico); the Riccardi and Pazzi chapels (Gozzoli and Perugino); at Milan, in the Santa Maria delle Grazie, the "Last Supper," by Leonardo, and at Padua, the famous Arena chapel (Giotto).

The Vatican galleries, though best known for their

Private and semi-private galleries.

statuary, have fine examples of painting, chiefly of the Italian school; the most famous easel picture is Raffaello's "Transfiguration," but the Stanze, apartments entirely decorated by painting, are even more famous. In England three royal palaces are open to the public—Hampton Court (Mantegna), Windsor (Van Dyck, Zuccarelli), and Kensington (portraits). At Buckingham Palace the Dutch pictures are admirable, and Queen Victoria lent the celebrated Raffaelle cartoons to the Victoria and Albert Museum. Semi-private collections belong to Dulwich College (Velasquez and Watteau), Oxford University (Italian drawings), the Soane Museum (Hogarth and English school), and the Royal Academy (Leonardo). Among private collections the most important are the Harrach, and Prince Liechtenstein (Vienna), the Six Gallery (Amsterdam), Mrs T. Gardner, of Boston (Italian), Prince Corsini (Florence). In Great Britain there are immense riches in private houses, though many collections have been dispersed. The most noteworthy belong to the dukes of Devonshire and Westminster, Lord Ellesmere, Captain Holford (including the masterpiece of Cuyp), Mr L. Mond, Lord Lansdowne, Miss Rothschild. The finest private collection belongs to Lord Cowper, his gallery of Van Dyck's work being quite the best in the world.

Periodical and commercial.

Many galleries are devoted to periodical exhibitions in London; the Royal Academy is the leading agency of this character, having held exhibitions since 1769. Its loan exhibitions of Old Masters are most important. Similar enterprises, heralded by the Grosvenor Gallery, are the New Gallery, opened in 1888, the Grafton Gallery, and others. There are also old-established societies of etchers, water-colourists, &c. A feature common to these exhibitions is that the public always pays for admission, though they differ from the commercial exhibitions, becoming more common every year, in which the work of a single school or painter is shown for profit. But the annual exhibitions at the Guildhall, under the auspices of the Corporation, are free. The great periodical exhibition of French art is known as the Salon, and for some years it has had a rival in the Champ de Mars exhibition. These two societies are now respectively housed in the Grand Palais and Petit Palais, in the Champs Elysées, which were erected in connexion with the Paris Exhibition of 1900, but with the ultimate object of being devoted to the service of the two Salons. Berlin, Rome, Vienna, and other Continental towns have regular exhibitions of original work.

The best history of art galleries is found in their official and other catalogues, see article Museums. See also L. Viardot, *Les musées d'Italie*, &c., 3 vols. Paris, 1842, 1843, 1844.—Annual Reports, official, of National Portrait Gallery, National Galleries of England, Ireland, and Scotland; Civil Service Estimates, class iv. official. See also the series edited by Lafenestre and E. Richtenberger: *Le Louvre, La Belgique, Le Hollande, Florence, Belgique.*—A. Lavice. *Revue des musées de France, ... d'Allemagne, ... d'Angleterre, ... d'Espagne, ... d'Italie, ... de Belgique, de Hollande et de Russie.* Paris, 1862-72.—E. Michel. *Les musées d'Allemagne.* Paris, 1886.—Kate Thompson. *Public Picture Galleries of Europe*, 1880.—C. L. Eastlake. *Notes on Foreign Picture Galleries.*—Lord Ronald Gower. *Pocket Guide to Art Galleries (public and private) of Belgium and Holland*, 1875; and many works, albums, and so forth, issued mainly for the sake of the illustrations. (B.)

Art Museums. See Museums.

Art Sales.—The practice of selling objects of art by auction in England dates from the latter part of the 17th century, when in most cases the names of the auctioneers were suppressed. Evelyn (under date 21st June 1693) mentions a "great auction of pictures (*Lord Melford's*) in the Banquetting House, Whitehall," and the practice is frequently referred to by other contemporary and later writers. Before the introduction of regular auctions the practice was, as in the case of the famous collection formed by *Charles I.*, to price each object and invite purchasers, just as in other departments of commerce. But this was a slow process, especially in the case of pictures, and lacked the incentive of excitement. The first really important art collection to come under the hammer was that of *Edward, Earl of Oxford*, dispersed by Cock, under the Piazza, Covent Garden, on 8th March 1741-42 and the five following days, six more days being required by the coins. Nearly all the leading men of the day, including Horace Walpole, attended or were represented at this sale, and the prices varied from five shillings for an anonymous bishop's "head" to 165 guineas for Vandyck's group of "Sir Kenelm Digby, lady, and son." The next great dispersal was *Dr Richard Mead's* extensive collection, of which the pictures, coins, and gems, &c., were sold by Langford in February and March 1754, the sale realizing the total, unprecedented up to that time, of £16,069. The thirty-eight days' sale (1786) of the *Duchess of Portland's* collection is very noteworthy, from the fact that it included the celebrated Portland vase, now in the British Museum. Many other interesting and important 18th-century sales might be mentioned. High prices did not become general until the *Calonne, Trumbull* (both 1795) and *Bryan* (1798) sales. As to the quality of the pictures which had been sold by auction up to the latter part of the 18th century, it may be assumed that this was not high. The importation of pictures and other objects of art had assumed extensive proportions by the end of the 18th century, but the genuine examples of the Old Masters probably fell far short of 1 per cent. England was felt to be the only safe asylum for valuable articles, but the home which was intended to be temporary often became permanent. Had it not been for the political convulsions on the Continent, England, instead of being one of the richest countries in the world in art treasures, would have been one of the poorest. This fortuitous circumstance had, moreover, another effect, in that it greatly raised the critical knowledge of pictures. Genuine works realized high prices as, for example, at *Sir William Hamilton's* sale (1801) when Beckford paid 1300 guineas for the little picture of "A Laughing Boy" by Leonardo da Vinci; and when at the *Lafontaine* sales (1807 and 1811) two Rembrandts each realized 5000 guineas, "The Woman taken in Adultery," now in the National Gallery, and "The Master Shipbuilder," now at Buckingham Palace. The *Beckford* sale of 1823 (41 days, £43,869) was the forerunner of the great art dispersal of the 19th century; *Horace Walpole's* accumulation at Strawberry Hill, 1842 (24 days, £33,450), and the *Stowe* collection, 1848 (41 days, £75,562) were also celebrated. They comprised every phase of art work, and in all the quality was of a very high order. They acted as a most healthy stimulus to art collecting, a stimulus which was further nourished by the sales of the superb collection of *Ralph Bernal* in 1853 (32 days, £62,690), and of the almost equally fine but not so comprehensive collection of *Samuel Rogers*, 1856 (18 days, £42,367). Three years later came the dispersal of the 1500 pictures which formed *Lord Northwick's* gallery at Cheltenham (pictures and works of art, 18 days, £94,722).

Towards the latter part of the first half of the 19th century an entirely new race of collectors gradually came into existence; they were for the most part men who had made, or were making, large fortunes in the various industries of the midlands and north of England and other centres. They were untrammelled by "collecting" traditions, and their patronage was almost exclusively extended to the artists of the day. The dispersals of these collections began in 1863 with the *Bicknell Gallery*, and continued at irregular intervals for many years, *e.g.*, *Gillott* (1872), *Mendel* (1875), *Wynn Ellis* and *Albert Levy* (1876), *Albert Grant* (1877), and *Munro of Novar* (1878). These patrons purchased at munificent prices either direct from the easel or from the exhibitions not only pictures in oils but also water-colour drawings. As a matter of investment their purchases frequently realized far more than the original outlay; sometimes, however, the reverse happened, as, for instance, in the case of Landseer's "Otter Hunt," for which Baron Grant is said to have paid £10,000 and which realized shortly afterwards only 5650 guineas. One of the most striking features of the sales of the 'seventies was the high appreciation of water-colour drawings. At the *Gillott* sale 160 examples realized a total of £27,423, when Lord Dudley paid 3150 guineas for Turner's "Bamborough Castle"; and three years later at the *Quilter* sale (1875), when David Cox's "Hayfield," for which a dealer had paid the artist 50 guineas in 1850, realized 2810 guineas. Water-colour drawings have never recovered the inevitable effect of the "boom" in the 'seventies, but even within late years prices at auction indicate a distinctly upward tendency; in 1895 David Cox's "Welsh Funeral" (which cost about £20) sold for 2400 guineas, and in the same sale Sir Edward Burne-Jones's "Hesperides" realized 2560 guineas. The demand for works by modern artists, whose works sold at almost fabulous prices thirty years ago, has greatly declined; but during all its *furore* there was still a small band of collectors to whom the works of the Old Masters more especially appealed. The dispersal of such collections as the *Bredel* (1875), *Watts Russell* (1875), *Foster of Clewer Manor* (1876), the *Hamilton Palace* (17 days, £397,562)—the greatest art sale in the annals of Great Britain—*Bale* (1882), *Leigh Court* (1884), and *Dudley* (1892) contained, as did many minor collections sold each season, many very fine examples of the Old Masters which found eager purchasers at high prices. It has been frequently said that the Old Masters are no longer in fashion with collectors, but the fact is that first-rate examples are now rarely offered for sale; when they do occur prices are invariably high. Scarcely a season passes without affording a proof of this, the most striking one of all being the £24,250 realized by the pair of Vandyck portraits of a Genoese senator and his wife in the *Peel* sale, 1900.

The chief feature of the picture sales of the last quarter of the 19th century was the demand for works—more particularly female portraits—by Reynolds and his contemporaries. The origin of this fashion is perhaps traceable to the exhibitions held at South Kensington, 1867 and 1868, and the annual winter exhibitions at Burlington House, which revealed an unsuspected wealth and charm in the works of many English artists who had almost fallen into oblivion. The prices which have been paid at auction during recent years for such pictures can only be described as fabulous, and a few of the records may be quoted—Reynolds's "Lady Betty Delmé," 1894, 11,000 guineas; Romney's "The Ladies Spencer," 1896, 10,500 guineas; Gainsborough's "Duchess of Devonshire" (the picture which so mysteriously disappeared a few days after the sale, and which was as mysteriously restored to its owners, Messrs Agnew, in April 1901), 1876, 10,100 guineas; Constable's "Stratford Mill," 1895, 8500 guineas; and Turner's "Wreckers," 1897, 7600 guineas. Since 1880 works of the modern Continental schools—more especially the French—have become popular with English collectors, and high prices have accordingly figured in auction sales. The "appreciation" is, however, circumscribed, and perhaps does not extend much beyond a dozen well-known names, of which the principal—with a few of their chief pictures—are Rosa Bonheur, "Denizens of the Highlands," *Bolckow* sale, 1888, 5550 guineas; Jules Breton, whose "Girls going to the First Communion" realized £9100 in New York in 1886; Corot, Fortuny, Gallait, Gérôme, Greuze, Israëls; Meissonier (of whose works sold by auction two may be mentioned): "Napoleon I. in the Campaign of Paris," 12¼ inches by 9¼ inches, for which Mr Ruskin gave 1000 guineas in 1869 and which realized 5800 guineas in 1882, and "The Sign Painter," which in the *Bolckow* sale of 1891 realized 6450 guineas; Munkacsy, Troyon, and Verboeckhoven.

"Specialism" is the one important development in art collecting which has manifested itself during the last half century. This accounts for and explains the high average quality of the *Wellesley* (1866), the *Buccleuch* (1888), and the *Holford* (1893) collections of drawings by the Old Masters; for the *Sibson* Wedgwood (1877), the *Duc de Forli* Dresden (1877), the *Shuldham* blue and white porcelain (1880), the *Warwick* enamels (1896), the *Dudley* porcelain (1886), the *Massey-Mainwaring* gold boxes (1897), and also for the objects of art collected by *Mr Magniac* (1892) and by *Herr Heckscher* (1898). Very many other illustrations in nearly every department of art collecting might be quoted—the superb series of *Marlborough gems* (1875 and 1899) might be included in this category but for the fact that it was formed chiefly in the 18th century. The appreciation—commercially at all events—of mezzotint portraits and of portraits printed in colours, after masters of the early English school, was one of the most remarkable features in art sales during the last years of the 19th century. The shillings of fifty years before were then represented by pounds. The Fraser collection (4th to 6th December 1900) realized about ten times the original outlay, the mezzotint of the "Sisters Frankland," after Hoppner, by W. Ward, selling for 290 guineas as against 10 guineas paid for it about thirty years previously. The H. A. Blyth sale (11th to 13th March 1901, 346 lots, £21,717 : 10s.) of mezzotint portraits was even more remarkable, and as a collection it was the choicest sold within recent times, the engravings being mostly in the first state. The record prices were numerous, and, in many cases, far surpassed the prices which Sir Joshua Reynolds received for the original pictures; *e.g.*, the exceptionally fine example of the first state of the "Duchess of Rutland," after Reynolds, by V. Green, realized 1000 guineas, whereas the artist received only £150 for the painting itself. Even this unprecedented price for a mezzotint portrait was exceeded on 30th April 1901, when an example of the first published state of "Mrs Carnac," after Reynolds, by J. R. Smith, sold for 1160 guineas. Such prices as these and many others which might be quoted are exceptional, but they were paid for objects of exceptional rarity or quality. The demand for the finest works of art of all descriptions is much greater than the supply. As an illustration of the magnitude of the art sale business it may be mentioned that the "turnover" of one firm in London alone has occasionally exceeded £1,000,000 annually.

Bibliography.—The chief compilations dealing with art sales in Great Britain are—*Art Sales*, by G. Redford (1888), and *Memorials of Christie's*, by W. Roberts (1897); whilst other books containing much important matter are W. Buchanan's *Memoirs of Painting*; *The Year's Art*, 1880 and each succeeding year; *The Connoisseur*, by F. S. Robinson; and *Les ventes de tableaux, dessins et objets d'art au XIXe Siècle* (chiefly French), by L. Soullié. (W. R.*)

Art Societies.—In banding themselves into societies and associations artists have always been especially remarkable. The fundamental motive of such leaguing together is apparent, for, by the establishment of societies, it becomes possible for the working members of these to hold exhibitions and thereby to obtain some compensation or reward for their labours. With the growth of artistic practice and public interest, however, art societies have been instituted where this primary object is either absent or is allied to others of more general scope. The furtherance of a cult and the specializing of work have also given rise to many new associations in Great Britain, besides the Royal Academy (*q.v.*). At the outset, therefore, it will be well to mention the leading art societies thus described. The (now *Royal*) *Society of Painters in Water Colours*, founded in 1804, and the (now *Royal*) *Society of British Artists* (1823), are typical of those societies which exist merely for purposes of holding exhibitions and conferring diplomas of membership. The *Artists' Society*, formed in 1830, has for its object the providing of facilities to enable its members to perfect themselves in their art. To this end there is a good library of works on art, and abundant opportunities are afforded for general study from the life. In the furtherance of a cult the *Japan Society*, devoted to the encouragement of the study of the arts and industries of Japan, is a typical example; and the *Society of Mezzotint Engravers* is representative of those bodies formed in the interests of particular groups of workers. One of the remarkable features in the history of art in Great Britain has been the rapid increase of the artistic rank and file. Taking the number of exhibitors at the principal London and provincial exhibitions, it is found that in the period 1885-1900 the ranks were doubled. At the end of the 19th century it was estimated that there were quite 7000 practising artists. Coincident with this astonishing development there has been a corresponding addition of new art societies and the enlargement of older bodies. For instance, the membership of the *Royal Society of British Artists* advanced in the period mentioned from 80 to 150. Similar extensions can be noted in other societies, or in such a case as that of the *Royal Institute of Painters in Water Colours*, where the membership has remained fixed, it is to be noticed that more space is given to the works of outsiders. But the expansion of older exhibiting societies has not proved sufficient. Portrait painters, pastellists, designers, miniaturists, and women artists have felt the necessity of forming separate coteries. Interesting though these movements from within may be, the growth of societies originating in the spirit of altruism associated with such names as *Ruskin* and *Kyrle* is equally instructive. Nearly all these are the products of the last quarter of the century and include the *Sunday Society*, which in 1896 secured the Sunday opening of the National Museums and Galleries in the Metropolis.

The specializing of study and work has also given rise to much artistic endeavour. For a long time archæology—British and Egyptian—claimed almost exclusive attention. Latterly the arts of India and Japan have engaged much notice, and societies have been organized to further their study. Finally, bands of workers in particular branches of art have felt the need of clubbing together in order to protect their special interests. A slight suspicion of trade-unionism is attached to some of these; but on the whole the establishment of such bodies as the *Society of Illustrators*, the *Society of Designers*, and the *Society of Mezzotint Engravers* has been with a view to advancing the public knowledge of the merits of these branches of artistic enterprise.

Exhibiting Societies.—(*a*) *Old Established.*—These in London are: The *Royal Academy*, the *Royal Water Colour Society*, the *Royal Institute of Painters in Water Colours*, the *Society of Oil Painters*, and the *Royal Society of British Artists*. In the provinces, the *Birmingham Royal Society of Artists* has been in existence seventy-four years, and has a life academy with professors attached. (*b*) *Modern.*—In this category are many which reflect the freshness and spirit of the enterprise shown during the last twenty-five years. Such a body as the *New English Art Club*, founded in 1885 as a protest against all other art societies, achieves its purpose by exhibition only. The *Royal Society of Painter-Etchers and Engravers*, consisting of fellows and associates, not exceeding 150 in all, conserves the interests of a numerous body of workers, and, in addition to holding exhibitions, confers diplomas (R.E. and A.R.E.) on the exhibitors of meritorious etchings or engravings. The *Society of Women Artists* (formerly the *Society of Lady Artists*) is wholly devoted to the display of works by female artists, and in 1891 the *Society of Portrait Painters* was formed to carry out the object conveyed in its title. Two associations advance the art of the miniature painter, and the *Pastel Society*, formed in 1898, holds displays of members' work at the Royal Institute Galleries. In Scotland there is the *Royal Scottish Academy*. The *Royal Scottish Society of Painters in Water Colours* (Glasgow) grants the title R.S.W. to its members, and the *Society of Scottish Artists* (Edinburgh), founded in 1891, has a membership of nearly 500 young artists. Other exhibiting societies which call for mention are: The *Yorkshire Union of Artists* (Leeds), which consolidates many local societies; the *Nottingham Society of Artists*, which also encourages drawing from the living model; and similarly the *Liver Sketching Club* (Liverpool), founded nearly thirty years ago, which, in addition to holding an annual exhibition, devotes four nights a week to drawing from life.

Societies of Instruction and Popular Encouragement.—It is under this head that the chief evidence of the modern art revival will be found. First it should be noted that there are very few societies designed for the artistic improvement of artists. The *Artists' Society* has already been mentioned; and the *Art Workers' Guild*, which meets at Clifford's Inn Hall, provides meetings, from which the public is excluded, where profitable discussions take place on questions of craft and design. But, as a rule, the art society, of which only artists are members, is organized for exhibition purposes or for the protection of interests. With regard to those societies of popular and educational intention the old *Society of Arts* in the Adelphi, founded in 1754, enjoys a good record. Numerous lectures on art subjects have from time to time been given, and in 1887 a scheme was devised by which awards are made to student-workers in design. The *Society for the Encouragement of the Fine Arts* (Conduit Street) has also laboured during the last half-century to increase a technical knowledge, its members holding conversazioni at various picture galleries. The *Artists' and Amateurs' Conversazione*, instituted in 1831, which used to meet at the Piccadilly Galleries and is now defunct, carried out a similar plan. Two other societies, now obsolete, should be mentioned whose methods were directly educational. The *Arundel Society*, which for many years promoted the knowledge of art by copying and publishing important works of ancient masters, issued to its members on payment of annual subscriptions, was eventually wound up on the last day of 1897. The *International Chalcographical Society*, formed for the study of the early history of engraving—its committee consisting of Messrs Sidney Colvin, Georges Duplessis, F. Lippmann, and Baron Edmond de Rothschild—also did useful work. Another association of painters, sculptors, architects, and engravers, the *Graphic Society*, ceased on the 29th October 1890. This was one of the most interesting of societies, and its meetings, at which rare works of art were exhibited and discussed, were held in the Flaxman Gallery at University College. A very active educational body, originated in 1888, namely the *Royal Drawing Society*, has for its definite object the teaching of drawing as a means of education. The methods of instruction are based on the facts that very young children try to draw before they can write, and that they have very keen perception and retentive memory. The society aims, therefore, at using drawing as a means of developing these innate characteristics of the young, and already nearly 300 important schools follow out its system. Lord Leighton, Sir John Millais, and Sir Edward Burne-Jones took an active part in the society's labours. The *Art for Schools Association*, founded in 1883, has also done steady work in endeavouring to provide schools with works of art. These are chiefly reproductions of standard works of art or of historical and natural subjects. The wave of enthusiasm aroused by Mr Ruskin's teachings caused *Societies of the Rose* to be founded in London, Manchester, Sheffield, Birmingham, Aberdeen, and Glasgow; but some of these eventually ceased active work, to be revived again, however, by the *Ruskin Union*, formed in the year of the great writer's death (1900). Most of these societies were formed in 1879; but it should not be forgotten that two years earlier the *Kyrle Society* was started with the object of bringing the refining and cheering influences of natural and artistic beauty to the homes of the people. Under the presidency of Earl Brownlow, the *Home Arts and Industries Association* continues a work which was started in 1884, and anticipated much of the present system of technical education. Voluntary teachers organize classes for working people, at which a practical knowledge of art handiwork is taught. In remote or poor districts isolated workers are also assisted. Training classes for voluntary teachers are held in such varied pursuits as bent iron work, spinning, embroidery, and smocking. An interesting type of society has been established in Bolton, Lancashire. Under the title of an *Arts Guild* the members, numbering over 200, devote themselves to the advancement of taste in municipal improvements.

SOCIETIES OF SPECIAL STUDY, PRACTICE, AND PROTECTION.—Under this head should be placed those associations which affect a cult, or are composed of particular workers, or which protect public or private interests. Perhaps the chief of the first kind is the *Japan Society*, which, since its inception in 1892, has been joined by over 900 members interested in matters relating to Japanese art and industries. The *Dürer Society*, formed in 1897, has for its main object the reproduction of works by Albert Dürer, and his German and Italian contemporaries, and is in a way the successor to the defunct Arundel Society. In this category of special study the *Society for the Encouragement and Preservation of Indian Art* may also be placed, and the *Egypt Exploration Fund*. The *Ruskin Union* may also be mentioned again in this connexion. Of the societies of special practice it has already been noticed that some are purely exhibiting associations, such as the *Portrait Painters*, the *Pastel Society*, and the two miniature bodies. The formation of the *Society of Mezzotint Engravers* in 1898 is an example of the leaguing together of particular workers to call attention to their interests. Original and translator engravers, together with collectors and connoisseurs, comprise the membership. The decaying art of wood engraving is also fostered by the *International Society of Wood Engravers*, and the *Society of Designers*, founded in 1896, safeguards the interests of professional designers for applied art, without holding exhibitions. Special practice and protection are also considered by the *Society of Illustrators*, composed of artists who work in black and white for the illustrated press. This society was inaugurated in 1894, and fifteen of the members of the committee must be active workers in illustration. As an instance of the tendency of art workers to combine, the *Society of Art Masters* is a good illustration. This is an association of teachers of art schools, controlled by the art branch of the Board of Education, and has a membership of over 200. Good work of another kind occupies the *National Trust for Places of Historic Interest or Natural Beauty*. The Council of the Trust includes representatives of such bodies as the National Gallery, the Royal Academy, the Royal Society of Painters in Water Colours, the Society of Antiquaries, the Royal Institute of British Architects, the Universities, Kyrle Society, Society for the Protection of Ancient Buildings, and the Selborne Society.

FOREIGN ART SOCIETIES.—The following are brief particulars of the chief art societies elsewhere than in Great Britain:—

AUSTRIA.—Vienna, *Vereinigung bildender Kuenstler Osterreichs* (Society of Austrian Painters) and the *Association of Viennese Artists* (L'Association des artistes de Vienne).

BELGIUM.—Brussels, *Société des Beaux Arts*, the *Libre Esthétique*, *Société des Aquarellistes et Pastellistes*, *Société royale Belge des Aquarellistes*, and numerous private societies (*cercles*) in Brussels, Antwerp, Liége, Ghent, and other cities.

FRANCE.—Paris, the *Société des Artistes Français* (The Salon), *Société Nationale des Beaux Arts* (The New Salon), *Société des Aquarellistes*. Exhibiting societies are the *Société des Artistes Indépendants*, *Société des Orientalistes*, and *Salon des Pastellistes*.

GERMANY.—The small local societies are affiliated to one large parent body, the *Deutsche Kunstlergenossenschaft*, in Berlin under the presidency of Anton von Werner. The *Deutsche Illustratorenverband* watches over the interests of illustrators and designers. In Munich there are two bodies—the Old Society of Artists, holding its exhibitions in the Glaspalast, and the *Secession*.

ITALY.—Four exhibiting societies: Rome, *Società in Arte Libertas*, *Scuola degli Aquarellisti*; Milan, *Famiglia Artistica*, *Societa degli Artiste*; Florence, *Circolo Artistico*; Naples, *Instituti di Belli Arti*.

PORTUGAL.—*Sociedade promotora das Bellas-Artes* and *Gremio Artistico*.

RUSSIA.—There is no exclusively art society of importance, but there is at St Petersburg the *Société Littéraire et Artistique*.

SPAIN.—Madrid, *L'Association des Artistes Espagnols*.

SWEDEN.—Stockholm, *Svenska Konstnarernas Forening*.

SWITZERLAND.—Berne, *La Société des Peintres et Sculpteurs Suisses*.

UNITED STATES.—New York, the *Academy of Fine Arts*, the *French Institute*; Boston, *Massachusetts Institute of Technology* (founded 1861). (A. C. R. C.)

Art Teaching.—It is the tendency of all departments of the human mind to outgrow their original limits. Traditions of teaching are long-lived, especially in art, and new ideas only slowly displace the old, so that art teaching as a whole is seldom abreast of the ideas and practice of the more advanced artists. The old academic system adapted to the methods and aims in art in the 18th century, which has been carried on in the principal art schools of Great Britain with but slight changes of method, consisted chiefly of a course of drawing from casts of antique statues in outline, and in light and shade, without backgrounds, of anatomical drawings, perspective, and drawing and painting from the living model. Such a training seems to be more or less a response to Lessing's definition of painting as "the imitation of solid bodies upon a plane surface." It seems to have been influenced more by the sculptor's art than any other. Indeed, the academic teaching from the time of the Italian Renaissance was no doubt principally derived from the study of antique sculpture; the proportions of the figure, the style, pose, and sentiment being all taken from Græco-Roman and Roman sculptures, discovered so abundantly in Italy from the 16th century onwards. As British ideas of art were principally derived from Italy, British academies endeavoured to follow the methods of teaching in vogue there in later times, and so the art student in Great Britain has had his attention and efforts directed almost exclusively to the representation of the abstract human form in abstract relief. Traditions in art, however, may sometimes prove helpful and beneficial, and preservative of beauty and character, as in the case of certain decorative and constructive arts and handicrafts in common use, such as those of the rural waggon-maker and wheelwright, and horse-harness maker (see ACADEMY, ROYAL).

Some schools of painting, sculpture, and architecture have preserved fine and noble traditions which yet allowed for individuality. Such traditions may be said to have been characteristic of the art of the Middle Ages. It often happens, too, when many streams of artistic influence meet, there may be a certain domination or ascendency of the traditions of one art over the others, which is injurious in its effects on those arts and diverts them from their true path. The domination of individualistic painting and sculpture over the arts of design during the last century or two is a case in point.

With the awakening of interest in industrial art—sharply separated by pedantic classification from fine art—which began about the middle of the 19th century, schools of design were established which included more varied studies. Even as early as 1836 a Government grant was made towards the opening of public galleries and the establishment of a normal school of design with a museum and lectures, and in 1837 the first school of design was opened at Somerset House. In 1840 grants were made to establish schools of the same kind in provincial towns, such as Manchester, Birmingham, Glasgow, Leeds, and Paisley. The names of G. Wallis in 1847, and Ambrose Poynter in 1850, are associated with schemes of art instruction adopted in the Government art schools, and the year 1851, the year of the Great Exhibition, was also marked by the first public exhibition of students' works, and the first institution of prizes and scholarships. In 1852 "the Department of Practical Art" was constituted, and a museum of objects collected at Marlborough House which afterwards formed the nucleus of the future museum at South Kensington. In 1853 "The Department of Science and Art" was established, and in 1857, under the auspices of Henry Cole, the offices of the department and the National Art Training School were removed from Marlborough House to South Kensington. Classes for instruction in various crafts had been carried on both at Somerset House and Marlborough House, and the whole object of the Government schools of design was to give an artistic training to the designer and craftsman, so that he could carry back to his trade or craft improved taste and skill. The schools, however, became largely filled by students of another type—leisured amateurs who sought to acquire some artistic accomplishment, and even in the case of genuine designers and craftsmen who developed pictorial skill in their studies, the attraction and superior social distinction and possibility of superior commercial value accruing to the career of a painter of easel pictures, diverted the schools from their original purpose.

For some time after the removal to South Kensington, during the progress of the new buildings, and under the direction of Godfrey Sykes and F. W. Moody, practical decorative work both in modelling and painting was carried out in the National Art Training School; but on the completion of these works, the school relapsed into a more or less academic school on the ordinary lines, and was regarded chiefly as a school for the training of art teachers and masters who were required to pass through certain stereotyped courses, and execute a certain series of drawings in order to obtain their certificates. Thus model-drawing, freehand outline, plant-drawing in outline, outline from the cast, light and shade from the cast, drawing of the antique figure, still life, anatomical drawings, drawing and painting from the life, ornamental design, historic studies of ornament, perspective, and geometry, were all taken up in a cut-and-dried way, as isolated studies, and with a view solely to obtaining the certificate or passing an examination. This theoretic kind of training though still in force, and though it enabled the department to turn out certificated teachers for the schools of the country of a certain standard, and to give to students a general theoretic idea of art, has been found wanting, since, in practice, when the student in design leaves his school and desires to take up practical work as a designer or craftsman, he requires *special* knowledge, and specialized skill in design for his work to be of use; and though he may be able to impart to others what he himself has laboriously acquired, the theoretic and general character of his training proves of little or no use, face to face with the ever shifting and changing demands of the modern manufacturer and the modern market.

A growing conviction of the inadequacy of the schools of the Science and Art Department (now the Board of Education), considered as training grounds for practical designers and craftsmen, led to the establishment of new technical schools in the principal towns of Great Britain. The circumstance of certain large sums, diverted from their original purpose of compensation to brewers, being available for educational purposes and at the disposal of the county councils and municipal bodies, provided the means for the building and equipment of these new technical schools, which in many cases are under the same roof as the art school in the provincial towns, although the connexion between the two is not so close as might be desirable. The art schools formerly managed by private committees and supported by private donors, assisted by the Government grants, are now, in the principal industrial towns of Great Britain, taken over by the municipality. Birmingham is singularly well organized in this respect, and its art school has long held a leading position. The school is well housed in a new building with class-rooms with every appliance, not only for the drawing, designing, and modelling side, but also for the practice of artistic handicrafts such as metal repoussé, enamelling, wood-carving, embroidery, &c. The municipality have also established a jewellery school, so as to associate the practical study of art with local industry. Manchester will shortly have a large new technical school, intended to combine the work of the existing technical school in Princess Street and the weaving school in Peter Street under one roof, with special classes for design; while the art school in Cavendish Street, with its museum, may remain as a high school of design, painting, and modelling. In Glasgow, which has now a distinct place in the modern development of art, both decorative and pictorial, under the headmastership of Mr Francis H. Newbery, the art schools are also under municipal management, and large new premises have been completed for the extension of work in the technical and practical direction. Leicester has an admirably equipped and organized art school in a fine building.

The important change involved in the incorporation of the Science and Art Department with the Board of Education has also led to a reorganization of the Royal College of Art. A special Council of Advice on art matters has been appointed, consisting of representatives of painting, sculpture, architecture, and design, who deal with the Royal College of Art, and appoint the professors who control the teaching in the classes for architecture, design and handicraft, decorative painting and sculpture, modelling, and carving. The council decide upon the curriculum, and examine and criticize the work of the college from time to time. They also advise the Board in regard to the syllabus issued to the art schools of the country, and act as referees in regard to purchases for the museum. New buildings for the Royal College of Art will be added to the new museum building now in course of erection. There will be a lower and a higher school in the college, and provision will be made for the practice of the artistic handicrafts. An etching and engraving class has existed since 1864. A stained-glass class was instituted in 1899, and these will be followed by classes for stone and marble carving, for metal work, and for pottery, while others will be added as space and organization admit.

Of other institutions for the teaching of art, outside the Science and Art Department, the following may be named: The Royal Drawing Society of Great Britain and Ireland, which was formed principally to promote the teaching of drawing in schools as a means of education. The system therein adopted differs from the ordinary drawing courses, and favours the use of the brush. Brush-work has generally been adopted for elementary work, too, by London school-board teachers, drawing being now a compulsory subject. Remarkable results have been obtained by the Alma Road board schools in the teaching of boys from eight to twelve by giving them spaces to fill with given forms—leaf shapes—from which patterns are constructed to fill the spaces, brush and water-colour being the means employed. At the Female School of Art in Queen Square, London, classes in drawing and painting from life are held, and decorative design is also studied. At the Herkomer Incorporated School at Bushey, directed by Prof. H. von Herkomer, R.A., according to his own methods, students are instructed in drawing, painting, and engraving. The school is limited to 100 students. The City and Guilds of London Institute has two departments for what is termed "applied" art, one at the South London School of Technical Art, and the other at the Art Department in the Technical College, Finsbury. There are also the Royal School of Art Needlework; the School of Art Wood-carving; and the School of Art at the Crystal Palace. The Slade School of Drawing, Painting, and Sculpture, University College, Gower Street, confines itself to drawing and painting from the antique and life, and exercise in pictorial composition. There are also lectures on anatomy and perspective. The Slade Professorships at Oxford and Cambridge Universities are concerned with the teaching and literature of art, but they do not concern themselves with the practice. There are also, in addition to the schools of art named and those in connexion with the Board of Education in the various districts of London and the country, many and various private schools and clubs, such as the Langham and "Heatherley's," chiefly concerned in encouraging drawing and painting from the life, and for the study of art from the pictorial point of view, or for the preparation of candidates for admission into the Royal Academy or other schools.

A general survey, therefore, of the various institutions which are established for the teaching of art in Great Britain gives the impression that the study of art is not neglected, although, perhaps, further inquiry might show that, compared to the great educational establishments, the proportion is not excessive. With the board schools teaching art, as well as the municipal art schools and schools in connexion with the Board of Education, the danger is of waste of energy and of overlapping in the various courses. This danger suggests that a well-defined progressive system might be arranged so that a school-board scholar who shows artistic ability might be enabled to pass on from the elementary classes in one school to the higher art and technical schools, secondary and advanced, without retracing his steps, thus escaping the depression of going over old ground.

The general movement of revival of interest in the arts of decorative design and the allied handicrafts, with the desire to re-establish their influence in art-teaching, has been due to many causes, among which the work of the Arts and Crafts Exhibition Society may count as important. From the leading members of this body the London County Council Technical Education Board, when it was face to face with the problem of organizing its new schools and its technical classes, sought advice and aid. Success has attended their schools, especially the Central School of Arts and Crafts at Morley Hall, Regent Street. The object of the school is to provide the craftsman in the various branches of decorative design with such means of improving his taste and skill as the workshop does not afford. It does not concern itself with the amateur or with theoretic drawing. The main difference in principle adopted in this school in the teaching of design is the absence of teaching design *apart from handicraft*. It is considered that a craftsman thoroughly acquainted with the natural capacities of his material and strictly understanding the conditions of his work, would be able, if he had any feeling or invention, to design appropriately in that material, and no designing can be good apart from a knowledge of the material in which it is intended to be carried out. It should be remembered too that graphic skill in representing the appearances of natural objects is one sort of skill, and the executive skill of the craftsman in working out his design, say, in wood or metal, is quite another. It follows that the works of drawing or design made by the craftsman would be of quite a different character from a pictorial drawing, and might be quite simple and abstract, while clear and accurate. The training for the pictorial artist and for the craftsman would, therefore naturally be different.

The character of the art-teaching adopted in any country must of course depend upon the dominant conception of art and its function and purpose. If we regard it as an idle accomplishment for the leisured few, its methods will be amateurish and superficial. If we regard art as an important factor in education, as a language of the intelligence, as an indispensable companion to literature, we shall favour systematic study and a training in the power of direct expression by means of line. We shall value the symbolic drawing of early civilizations like the Egyptian, and symbolic art generally, and in the history of decorative art we shall find the true accompaniment and illustration of human history itself. From this point of view we shall value the acquisition of the power of drawing for the purpose of presenting and explaining the facts and forms of nature. Drawing will be the most direct means at the command of the teacher to explain, to expound, to demonstrate where mere words are not sufficiently definite or explicit. Drawing in this sense is taking a more important place in our education, especially in primary education, though there is no need for it to stop there, and one feels it may be destined to take a more important position both as a training for the eye and hand and an aid to the teacher. Then, again, we may regard art more from its social aspect as an essential accompaniment of human life, not only for its illustrative and depicting powers, but also and no less for its pleasure-giving properties, its power of awakening and stimulating the observation and sympathy with the moods of nature, its power of touching the emotions, and above all of appealing to our sense of beauty. We shall regard the study of art from this point of view as the greatest civilizer, the most permeating of social and human forces. Such ideas as these, shared no doubt by all who take pleasure and interest in art, or feel it to be an important element in their lives, are crossed and often obscured by a multitude of mundane considerations, and it is probably out of the struggle for ascendency between these that our systems of art teaching are evolved. There is the demand of the right to live on the part of the artist, and the teacher of art. There is the demand on the part of the manufacturer and salesman for such art as will help him to dispose of his goods. In the present commercial rivalry between nations this latter demand is brought into prominent relief, and art is apt to be made a minister, or perhaps a slave to the market. These are but accidental relationships with art. All who care for art value it as a means of expression and for the pleasure and beauty it infuses into all it touches, or as essential and inseparable from life itself. Seeing then the importance of art from any point of view, individual, social, commercial, intellectual, emotional, economic, it should be important to us in our systems of art-teaching not to lose sight of the end in arranging the means—not to allow our teaching to be dominated by either dilettantism or commercialism, neither to be feeble for want of technical skill, nor to sacrifice everything to technique. The true object of art-teaching is very much like that of all education—to inform the mind, while you give skill to the hand—not to impose certain rigid rules, or fixed recipes and methods of work, but while giving instruction in definite methods and the use of materials, to allow for the individual development of the student and enable him to acquire the power to express himself through different media without forgetting the grammar and alphabet of design. Practice may vary, but principles remain, and there is a certain logic in art, as well as in reasoning. All art is conditioned in the mode of its expression by its material, and even the most individual kind of art has a convention of its own by the very necessities and means of its existence. Methods of expression, conventions alter as each artist, each age seeks some new interpretation of nature and the imagination—the well-springs of artistic life, and from these reviving streams continually flow new harmonies, new inventions, and recombinations, taking form and colour according to the temperaments which give them birth. (W. Cr.)

Arta, a town of Thessaly, in Greece, in the province of Arta, 59 miles N.N.W. of Mesolonghi, on the river Arta, which enters the Gulf of Arta some distance south of the town. The battle of Actium was fought near the mouth of the gulf in 29 B.C. The population is now about 7000.

ARTHROPODA.

ARTHROPODA is the name of one of the three sub-phyla into which one of the great phyla (or primary branches) of cœlomocœlous animals—the APPENDICULATA—is divided; the other two being respectively the Chætopoda and the Rotifera. The word "Arthropoda" was first used in classification by Siebold and Stannius (*Lehrbuch der vergleich Anatomie*, Berlin, 1845) as that of a primary division of animals, the others recognized in that treatise being Protozoa, Zoophyta, Vermes, Mollusca, and Vertebrata. The names Condylopoda and Gnathopoda have been subsequently proposed for the same group. The word refers to the jointing of the chitinized exo-skeleton of the limbs or lateral appendages of the animals included, which are, roughly speaking, the Crustacea, Arachnida, Hexapoda (so-called "true insects"), Centipedes, and Millipedes. This primary group was set up to indicate the residuum of Cuvier's Articulata when his class Annelides (the modern Chætopoda) was removed from that "embranchement." At the same time Siebold and Stannius renovated the group Vermes of Linnæus, and placed in it the Chætopods and the parasitic worms of Cuvier, besides the Rotifers and Turbellarian worms.[1]

The result of the knowledge gained in the last quarter of the 19th century has been to discredit altogether the group Vermes, thus set up and so largely accepted by German writers even at the present day. We have, in fact, returned very nearly to Cuvier's conception of a great division or branch, which he called Articulata, including the Arthropoda and the Chætopoda (Annelides of Lamarck, a name adopted by Cuvier), and differing from it only by the inclusion of the Rotifera. The name Articulata, introduced by Cuvier, has not been retained by subsequent writers. The same, or nearly the same, assemblage of animals has been called Entomozoaria by De Blainville (1822), Arthrozoa by Burmeister (1843), Entomozoa or Annellata by Milne-Edwards (1855), and Annulosa by M'Leay (1819), who was followed by Huxley (1856). The character pointed to by all these terms is that of a ring-like segmentation of the body. This, however, is not the character to which we now ascribe the chief weight as evidence of the genetic affinity and monophyletic (uni-ancestral) origin of the Chætopods, Rotifers, and Arthropods. It is the existence in each ring of the body of a pair of hollow *lateral appendages* or *parapodia*, moved by intrinsic muscles and penetrated by blood-spaces, which is the leading fact indicating the affinities of these great sub-phyla, and uniting them as blood-relations. The parapodia (Fig. 7) of the marine branchiate worms are the same things genetically as the "legs" of Crustacea and Insects (Figs. 9 and 10). Hence the term APPENDICULATA was introduced by Lankester (preface to the English edition of Gegenbaur's *Comparative Anatomy*, 1878) to indicate the group. The relationships of the Arthropoda thus stated are shown in the subjoined table:—

Phylum-APPENDICULATA	Sub-phylum	1. Rotifera.
	,,	2. Chætopoda.
	,,	3. Arthropoda.

The ROTIFERA are characterized by the retention of what appears in Molluscs and Chætopods as an embryonic organ, the velum or ciliated præoral girdle, as a locomotor and food-seizing apparatus, and by the reduction of the muscular parapodia to a rudimentary or non-existent condition in all present surviving forms except *Pedalion*. In many important respects they are degenerate—reduced both in size and elaboration of structure.

The CHÆTOPODA are characterized by the possession of horny epidermic chætæ embedded in the integument and moved by muscles. Probably the chætæ preceded the development of parapodia, and by their concentration and that of the muscular bundles connected with them at the sides of each segment, led directly to the evolution of the parapodia. The parapodia of Chætopoda are never coated with dense chitin, and are, therefore, never converted into jaws; the primitive "head-lobe" or prostomium persists, and frequently carries eyes and sensory tentacles. Further, in all members of the sub-phylum Chætopoda the relative position of the prostomium, mouth, and peristomium or first ring of the body, retains its primitive character. We do not find in Chætopoda that parapodia, belonging to primitively post-oral rings or body-segments (called "somites," as proposed by H. Milne-Edwards), pass in front of the mouth by adaptational shifting of the oral aperture. (See, however, 8.)

---

[1] As a matter of fact the group Arthropoda itself, thus constituted, was precisely identical in its area with the class Insecta of Linnæus, the Entoma of Aristotle. But by causes which it is not easy to trace the word "Insect" had become limited since the days of Linnæus to the Hexapod Pterygote forms to the exclusion of his Aptera. Lamarck's penetrating genius is chiefly responsible for the shrinkage of the word Insecta, since it was he who, forty years after Linnæus's death, set up and named the two great classes Crustacea and Arachnida (included by Linnæus under Insecta as the order "Aptera"), assigning to them equal rank with the remaining Insecta of Linnæus, for which he proposed the very appropriate class-name "Hexapoda." Lamarck, however, appears not to have insisted on this name Hexapoda, and so the class of Pterygote Hexapods came to retain the group-name Insecta, which is, historically or etymologically, no more appropriate to them than it is to the classes Crustacea and Arachnida. The tendency to retain the original name of an old and comprehensive group for one of the fragments into which such group becomes divided by the advance of knowledge—instead of keeping the name for its logical use as a comprehensive term, including the new divisions, each duly provided with a new name—is most curiously illustrated in the history of the word Physiology. Cicero says, "Physiologia naturæ ratio," and such was the meaning of the name *Physiologus*, given to a cyclopædia of what was known and imagined about earth, sea, sky, birds, beasts, and fishes, which for a thousand years was the authoritative source of information on these matters, and was translated into every European tongue. With the revival of learning, however, first one and then another special study became recognized—anatomy, botany, zoology, mineralogy, until at last the great comprehensive term Physiology was bereft of all its once-included subject-matter, excepting the study of vital processes pursued by the more learned members of the medical profession. Professional tradition and an astute perception on their part of the omniscience suggested by the terms, have left the medical men in English-speaking lands in undisturbed but illogical possession of the words physiology, physic, and physician.

The Arthropoda might be better called the "Gnathopoda," since their distinctive character is, that one or more pairs of appendages behind the mouth are densely chitinized and turned (fellow to fellow on opposite sides) towards one another so as to act as jaws. This is facilitated by an important general change in the position of the parapodia; their basal attachments are all more ventral in position than in the Chætopoda, and tend to approach from the two sides towards the mid-ventral line. Very usually (but not in the Onychophora = *Peripatus*) all the parapodia are plated with chitin secreted by the epidermis, and divided into a series of joints—giving the "arthropodous" or hinged character.

There are other remarkable and distinctive features of structure which hold the Arthropoda together, and render it impossible to conceive of them as having a polyphyletic origin, that is to say, as having originated separately by two or three distinct lines of descent from lower animals; and, on the contrary, establish the view that they have been developed from a single line of primitive Gnathopods which arose by modification of parapodiate annulate worms not very unlike some of the existing Chætopods. These additional features are the following—(1) All existing Arthropoda have an ostiate heart and have undergone "phlebœdesis," that is to say, the peripheral portions of the blood-vascular system are not fine tubes as they are in the Chætopoda and as they were in the hypothetical ancestors of Arthropoda, but are swollen so as to obliterate to a large extent the cœlom, whilst the separate veins entering the dorsal vessel or heart have coalesced, leaving valvate ostia (see Fig. 1*) by which the blood passes from a pericardial blood-sinus formed by the fused veins into the dorsal vessel or heart (see Lankester's *Zoology*, part ii., introductory chapter. A. & C. Black, 1900). The only exception to this is in the case of minute degenerate forms where the heart has disappeared altogether. The rigidity of the integument caused by the deposition of dense chitin upon it is intimately connected with the physiological activity and form of all the internal organs, and is undoubtedly correlated with the total disappearance of the circular muscular layer of the body-wall present in Chætopods. (2) In all existing Arthropoda the region in front of the mouth is no longer formed by the primitive prostomium or head-lobe, but one or more segments, originally post-oral, with their appendages have passed in front of the mouth (prosthomeres). At the same time the prostomium and its appendages cease to be recognizable as distinct elements of the head. The brain no longer consists solely of the nerve-ganglion-mass proper to the prostomial lobe, as in Chætopoda, but is a composite (syncerebrum) produced by the fusion of this and the nerve-ganglion-masses proper to the prosthomeres or segments which pass forwards, whilst their parapodia (= appendages) become converted into eye-stalks, and antennæ, or more rarely grasping organs. (3) As in Chætopoda, cœlomic funnels (cœlomoducts) *may* occur right and left as pairs in each ring-like segment or somite of the body, and some of these are in all cases retained as gonoducts and often as renal excretory organs (green glands, coxal glands of Arachnida, *not* crural glands, which are epidermal in origin); but true nephridia, genetically identical with the nephridia of earthworms, do not occur (on the subject of cœlom, cœlomoducts, and nephridia, see the introductory chapter of part ii. of Lankester's *Treatise on Zoology*).

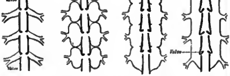


Fig. 1*.—Diagram to show the gradual formation of the Arthropod pericardial blood-sinus and "ostiate" heart by the swelling up (phlebœdesis) of the veins entering the dorsal vessel or heart of a Chætopod-like ancestor. The figure on the left represents the condition in a Chætopod, that on the right the condition in an Arthropod, the other two are hypothetical intermediate forms. (After Lankester, *Q. J. Mic. Sci.* vol. xxxiv. 1893.)

Tabular Statement of the Grades, Classes, and Subclasses of the Arthropoda.—It will be convenient now to give in the clearest form a statement of the larger subdivisions of the Arthropoda which it seems necessary to recognize at the present day. The justification of the arrangement adopted will form the substance of the rest of the present article. The orders included in the various classes are not discussed here, but are treated of under the following titles:—Peripatus (Onychophora), Myriapoda (Diplopoda and Chilopoda), Arachnida, Insecta (Hexapoda), and Crustacea.

Sub-Phylum ARTHROPODA (of the Phylum Appendiculata).

Grade A. **Hyparthropoda** (hypothetical forms connecting ancestors of Chætopoda with those of Arthropoda).
Grade B. **Protarthropoda.**
  Class Onychophora.
    Ex.—*Peripatus.*
Grade C. **Euarthropoda.**
  Class 1. Diplopoda.
    Ex.—*Julus.*
  Class 2. Arachnida.
    Grade *a.* Anomomeristica.
      Ex.—*Phacops.*
    Grade *b.* Nomomeristica.
      (*a*) Pantopoda.
        Ex.—*Pycnogonum.*
      (*b*) Euarachnida.
        Ex.—*Limulus, Scorpio, Mygale, Acarus.*
  Class 3. Crustacea.
    Grade *a.*—Entomostraca.
      Ex.—*Apus, Branchipus, Cyclops, Balanus.*
    Grade *b.* Malacostraca.
      Ex.—*Nebalia, Astacus, Oniscus, Gammarus.*
  Class 4. Chilopoda.
    Ex.—*Scolopendra.*
  Class 5. Hexapoda (syn. Insecta Pterygota).
    Ex.—*Locusta, Phryganea, Papilio, Apis, Musca, Cimex, Lucanus, Machilis.*

Incertæ sedis—Tardigrada, Pentastomidæ (degenerate forms).

The Segmentation of the Body of Arthropoda.—The body of the Arthropoda is more or less clearly divided into a series of rings, segments, or somites which can be shown to be repetitions one of another, possessing identical parts and organs which may be larger or smaller, modified in shape or altogether suppressed in one somite as compared with another. A similar constitution of the body is more clearly seen in the Chætopod worms. In the Vertebrata also a repetition of units of structure (myotomes, vertebræ, &c.)—which is essentially of the same nature as the repetition in Arthropods and Chætopods, but in many respects subject to peculiar developments—is observed. The name "metamerism" has been given to this structural phenomenon because the "meres," or repeated units, follow one another in line. Each such "mere" is often called a "metamere." This is not the place in which to discuss the origin and essential nature of "metamerism" or "metameric segmentation." Nevertheless, a satisfactory consideration of the structure of the Arthropoda demands a knowledge of what may be called the laws of metamerism. These are not so fully ascertained or formulated as might be expected. The repetition of parts, which we note as metamerism, is, as Haeckel, Bateson, and others have recognized, only a special case of a tendency of the organic body to repetition of structural units or parts which finds one expression in bilateral symmetry. In certain worms (the Cestoidea and some Planarians) metameric segmentation is accompanied by the separation of the completed metameres one by one from the older (anterior) extremity of the chain (strobilation), but it by no means follows that metameric segmentation has a necessary origin in such completion and separation of the "meres." On the contrary, metamerism seems to arise from a property of organisms which is sometimes more (eumerogenesis) and sometimes less (dysmeregenesis) fully exhibited, and in some groups not exhibited at all. The most complete and, at the same time, simplest instances of metameric segmentation are to be seen in the larger Chætopods, where some hundreds of segments succeed one another—each practically indistinguishable in structure from the segment in front or from that behind; muscles, right and left appendage or parapodium, colour-pattern of the skin, gut, blood-vessels, cœlom, nephridia, nerve-ganglion, and nerves are precisely alike in neighbouring segments. The segment which is least like the others is the first, for that carries the mouth and a lobe projecting beyond it—the prostomium. If (as sometimes happens) any of the hinder segments completes itself by developing a prostomium, the chain breaks at that point and the segment which has developed a prostomium becomes the first or head-bearing segment of a new individual. Compare such an instance of metameric segmentation with that presented by one of the higher Arthropods—*e.g.*, the crayfish. Here the somites are not so clearly marked in the tegumentary structures; nevertheless, by examining the indications given by the paired parapodia, we find that there are twenty-one somites present—a limited definite number which is also the precise number found in all the higher Crustacea.

We can state as a First Law[1] of metamerism or somite formation that it is either indefinite in regard to number of metameres or somites produced or is definite. Animals in the first case we call anomomeristic; those in the second case, nomomeristic. The nomomeristic condition is a higher development, a specialization, of the anomomeristic condition.

The Second Law, or generalization, as to metamerism which must be noted is that the meres or somites (excepting the first with its prostomium) may be all practically alike or may differ from one another greatly by modification of the various constituent parts of the mere or somite. Metamerized animals are either homœomeric or heteromeric. The reference to the variation in the form of the essential parts contained in a "metamere" or "somite" introduces us to the necessity of a general term for these constituent or subordinate parts; they may be called "meromes" (μέρος). The meromes present in a metamere or somite differ in different annulate or segmented animals according to the general organization of the group to which the animal belongs. As a matter of convenience we distinguish in the Arthropod as meromes, first, the tegumentary chitinized plates called terga, placed on the dorsal aspect of the somites; second, the similar sternal plates. In Chætopods we should take next to these the masses of circular and longitudinal muscular fibres of the body-wall and the dorso-ventral muscles. The latter form the third sort of merome present in the Arthropods. The fourth kind of merome is constituted by the parapodia or appendages; the fifth by the cœlomic pouches and their ducts and external apertures (cœlomo-ducts), whether renal or genital. The sixth by the blood-vessels of the somite; the seventh by the bit of alimentary tract which traverses it; and the eighth by the neuromere (nerve ganglion pair, commissures, connectives, and nerve branches).

It becomes apparent from this enumeration that there are a good many important elements or "meromes" in an Arthropod metamere or somite which can become the subject of heteromerism or, to use a more apt word, of "heterosis." It is all the more necessary to insist upon this inasmuch as there is a tendency in the discussion of the segmentation of the Arthropod body to rely exclusively upon the indications given by the tegumentary chitinous plates and the parapodia.

The Third Law of metamerism is that heteromerism may operate in such a way as to produce definite regions of like modification of the somites and their appendages, differing in their modification from that observed in regions before and behind them. It is convenient to have a special word for such regions of like meres, and we call each a tagma (ταγμα, a regiment). The word "tagmosis" is applicable to the formation of such regions. In the Chætopods tagmosis always occurs to a small extent so as to form the head. In some Chætopods, such as Chætopterus and the sedentary forms, there is marked tagmosis, giving rise to three or even more tagmata. In Arthropods, besides the head, we find very frequently other tagmata developed. But it is to be noted that in the higher members of each great class or line of descent, the tagmosis becomes definite and characteristic just as do the total number of meres or somites, whilst in the lower grades of each great class we find what may be regarded as varying examples of tentative tagmosis. The terms nomotagmic and anomotagmic are applicable with the same kind of implication as the terms nomomeristic and anomomeristic.

The Fourth Law of metamerism (auto-heterosis of the meromes) is that the meromes of a somite or series of somites may be separately and dissimilarly affected by heteromerism. It is common enough for small changes only to occur in the inner visceral meromes whilst the appendages and terga or sterna are largely changed in form. But of equal importance is the independent "heterosis" of these visceral meromes without any corresponding heterosis of the body wall. As instances, we may cite the gizzards of various earthworms and the special localization of renal, genital, and gastric meromes, with obliteration elsewhere, in a few somites in Arthropoda.

The Fifth Law, relating also to the independence of the meromes as compared with the whole somite, is the law of autorhythmus of the meromes. Metamerism does not always manifest itself in the formation of complete new segments; but one merome may be repeated so as to suggest several metameres, whilst the remaining meromes are, so to speak, out of harmony with it and exhibit no repetition. Thus in the hinder somites of the body of Apus the Crustacean we find a series of segments corresponding apparently each to a complete single somite, but when the appendages are examined we find that they have multiplied without relation to the other meromes of a somite; we find that the somites carry from two to seven pairs of appendages, increasing in number as we pass backwards from the genital segment. The appendages are autorhythmic meromes in this case. They take on a quasi-independent metamerism and are produced in numbers which have no relation to the numbers of the body-rings, muscles, and neuromeres. This possibility of the *independent* metameric multiplication of a single merome must have great importance in the case of dislocated meromes, and no doubt has application to some of the metameric phenomena of Vertebrates.

A case which appears at first sight to be one of "autorhythmus" of the parapodia is that of the Diplopods (Julus, etc.), in which each apparent somite carries two pairs of legs or parapodia. It looks at first as though this were due to the independent multiplication of the legs; but it is not. Contrary to what obtains in Apus, we find in Julus that there is a well-marked somite in the embryo corresponding to each pair of legs and that the adult condition arises from a *fusion* of the tegumentary meromes of adjacent somites (see below "Fusion").

The Sixth Law is the law of dislocation of meromes. This is a very important and striking phenomenon. A merome, such as a pair of appendages (Araneæ) or a neuromere or a muscular mass (frequent), may (by either a gradual or sudden process, we cannot always say which) quit the metamere to which it belongs, and in which it originated, and pass by actual physical transference to another metamere. Frequently this new position is at a distance of several metameres from that to which the wandering merome belongs in origin. The movement is more usual from behind forwards than in the reverse direction; but this, probably, has no profound significance and depends simply on the fact that, as a rule, the head must be the chief region of development on account of its containing the sense organs and the mouth.

In the Vertebrata the independence of the meromes is more fully developed than in other metamerized animals. Not only do we get auto-heterosis of the meromes on a most extensive scale, but the dislocation of single meromes and of whole series (tagmata) of meromes is a common phenomenon. Thus, in fishes the pelvic fins may travel forwards to a thoracic and even jugal position in front of the pectoral fins; the branchiomeromes lose all relation to the position of the meromes of muscular, skeletal, cœlomic, and nervous nature, and the heart and its vessels may move backwards from their original metameres in higher Vertebrates carrying nerve-loops with them.

---

[1] The word "Law" is used in this summary merely as a convenient heading for the statement of a more or less general proposition.

The **Seventh Law** of metamerism is one which has been pointed out to the writer by Mr. E. S. Goodrich of Merton College, Oxford. It may be called the law of "translation of heterosis." Whilst actual physical transference of the substance of meromes undeniably takes place in such a case as the passage of the pelvic fins of some fishes to the front of the pectorals, and in the case of the backward movement of the opisthosomatic appendages of spiders, yet the more frequent mode in which an alteration in the position of a specialized organ in the series or scale of metameres takes place is *not* by migration of the actual material organ from somite to somite, but by translation of the *quality* or morphogenetic peculiarity from somite to somite accompanied by correlative change in all the somites of the series. The phenomenon may be compared to the transposition of a piece of music to a higher or lower key. It is thus that the lateral fins of fishes move up and down the scale of vertebral somites; and thus that whole regions (tagmata), such as those indicated by the names cervical, thoracic, lumbar, and sacral, are translated (accompanied by terminal increase or decrease in the total number of somites) so as to occupy differing numerical positions in closely allied forms (cf. the varying number of cervical somites in allied Reptiles and Birds).

What, in this rapid enumeration, we will venture to call the **Eighth Law** of metamerism is the law of homœosis, as it is termed by Bateson (1). Homœosis is the making of a merome into the likeness of one belonging to another metamere, and is the opposite of the process of "heterosis"—already mentioned. We cite this law here because the result of its operation is to *simulate* the occurrence of dislocation of meromes and has to be carefully distinguished from that process. A merome can and does in individual cases of abnormality assume the form and character of the corresponding merome of a distant somite. Thus the antenna of an insect has been found to be replaced by a perfectly well-formed walking leg. After destruction of the eye-stalk of a shrimp a new growth appears, having the form of an antenna. Other cases are frequent in Crustacea, as individual abnormalities. They prove the existence in the mechanism of metamerized animals, of structural conditions which are capable of giving these results. What those structural conditions are is a matter for separate inquiry, which we cannot even touch here. It is not improbable that homœosis of distant meromes may have given rise to permanent structural changes characteristic of whole groups of Arthropoda, supposing the abnormality once established to be favoured by natural selection. Possibly the chelate condition of the præ-oral appendages of Arachnida may be due to homœosis transferring the chelate form of post-oral limbs to what were previously antenniform rami.

We now come to the questions of the production of *new* somites or the addition of new somites to the series, and the converse problem of the suppression of somites, whole or partial. We state as the **Ninth Law** of metamerism "that new somites or metameres are added to a chain consisting of two or more somites by growth and gradual elaboration—what is called 'budding'—of the anterior border of the hindermost somite. This hindermost somite is therefore different from all the other somites and is called the 'telson.' However long or short or heteromerized the chain may be, new metameres or somites are only produced at the anterior border of the telson, except in the Vertebrata." That is the general law. But amongst some groups of metamerized animals partial exceptions to it occur. It is probably absolutely true for the Arthropoda from lowest to highest. It is not so certain that it is true for the Chætopoda and would need modification in statement to meet the cases of fissiparous multiplication occurring among Syllids and Naidids. In the Vertebrata, where tagmosis and heterosis of meromes and dislocation of meromes and tagmata are, so to speak, rampant, new formation of metameres (at any rate as represented by important meromes) takes place at more than one point in the chain. Such points are found where two highly diverse "tagmata" abut on one another. It is possible, though the evidence at present is entirely against the supposition, that at such points in Arthropoda new somites may be formed.[1] Such new somites are said to be "intercalated." The question of the intercalation of vertebræ in the Vertebrata has received some attention. It must be remembered that a vertebra even taken with its muscular, vascular and neural accessories is only a partial metamere—a merome, and that, so far as *complete* metameres are concerned, the Vertebrata do conform to the same law as the Arthropoda. Intercalation of meromes, branchial, vertebral and dermal (fin-supports) seems to have taken place in Vertebrata in the fishes, while in higher groups intercalation of vertebræ in large series has been accepted as the only possible explanation of the structural facts established by the comparison of allied groups. The elucidation of this matter forms a very important part of the work lying to the hand of the investigator of vertebrate anatomy, and it is possible that the application of Goodrich's law (the seventh of our list) may throw new light on the matter.

In regard to the diminution in the number of somites in the course of the historical development of those various groups of metamerized animals, which have undoubtedly sprung from ancestors with more numerous somites than they themselves possess, it appears that we may formulate the following laws as the tenth, eleventh, twelfth, and thirteenth laws of metamerism.

The **Tenth Law** is that individual somites tend to atrophy and finally disappear as distinct structures, most readily at the anterior and the posterior ends of the series constituting an animal body. This is very generally exhibited in the head of Arthropoda, where, however, the operation of the law is largely modified by fusion (see below). With regard to the posterior end of the body, the atrophy of segments does not, as a rule, affect the telson itself so much as the somites in front of it and its power of producing new somites. Sometimes, however, the telson is very minute and nonchitinized (Hexapoda).

The **Eleventh Law** may be stated thus: any somite in the series which is the anterior or posterior somite of a tagma may become atrophied, reduced in size, or partially aborted by the suppression of some of its meromes; and finally, such a somite may disappear and leave no obvious trace in the adult structure of its presence in ancestral forms. This is called the excalation of a somite. Frequently, however, such "excalated" somites are obvious in the embryo or leave some merome (*e.g.*, neuromere, muscle, or chitin-plate) which can be detected by minute observation (microscopic) as evidence of their former existence. The somite of the maxillipede (third post-oral appendage) of Apus cancriformis is a good example of a somite on its way to excalation. The third præ-oral and the præmaxillary somites of Hexapod insects are instances where the only traces of the vanished somite are furnished by the microscopic study of early embryos. The prægenital somite of the Arachnida is an example of a somite which is preserved in some members of the group and partially or entirely excalated in other cases, sometimes with fusion of its remnants to neighbouring somites.

The **Twelfth Law** of metamerism might very well be placed in logical order as the first. It is the *law of lipomerism*, and asserts that just as the metameric condition is produced by a change in the bodies of the descendants of unisegmental ancestors, so highly metamerized forms—*i.e.*, strongly segmented forms with specialized regions of differentiated metameres — may gradually lose their metamerized structure and become apparently and practically unisegmental animals. The change here contemplated is not the atrophy of terminal segments one by one so as to *reduce* the size of the animal and leave it finally as a single somite. On the contrary, no loss of size or of high organization is necessary. But one by one, and gradually, the metameric grouping of the bodily structures disappears. The cuticle ceases to be thickened in rings — the muscles of the body-wall overrun their somite boundaries. Internal septa disappear. The nerve-ganglia concentrate or else become diffused equally along the cords; one pair of renal cœlomoducts and one pair of genital cœlomoducts grow to large size and remain —the rest disappear. The appendages atrophy or become limited to one or two pairs which are widely dislocated from their ancestral position. The animal ceases to present any indication of metameric repetition of parts in its entire structure. Degrees in this process are frequently to be recognized. We certainly can observe such a change in the posterior region of some Arthropods, such as the hermit-crabs and the spiders. Admitting that the Echiurids are descended from Chætopoda, such a change has taken place in them, amounting to little short of complete lipomerism, though not absolutely complete.

Recent suggestions as to the origin of the Molluscs involve the supposition that such an effacement of once well-marked metamerism has occurred in them, leaving its traces only in a few structures such as the multiple gill-plumes and shell-shields of the Chitons and the duplicated renal sacs of Nautilus.

A further matter of importance in this connexion is that when the old metameres have been effaced a new secondary segmentation may arise, as in the jointed worm-like body of the degenerate Acarus, *Demodex folliculorum*.

---

[1] The curious case of superabundant parapodia in the hinder somites of Apus has already been cited and referred to as an example of autorhythmic multiplication of meromes. There is some reason for regarding the extra pairs of legs as being "intercalated" after the formation of the somite as a single unit or merome by growth from the telson. Supposing, as appears to be the case, that as the Apus increase in size, the number of extra pairs of legs on a non-terminal somite increases in number, these added meromes are certainly intercalated and represent incomplete intercalated metameres. The intercalation of new elements does not really go much further than this in Vertebrata, for a vertebra with its myoskeletal tissues is only a merome and not a complete metamere.

Such secondary annulation of the soft body calls to mind the secondary annulation of the metameres of leeches and some earthworms. Space does not permit of more than an allusion to this subject; but it is worth while noting that the secondary annuli marking the somites of Leeches and Lumbricidæ in definite number and character are perhaps comparable to the redundant pairs of appendages on the hinder somites of Apus, and are in both cases examples of independent repetition of tegumentary meromes—a sort of ineffectual attempt to subdivide the somite which only prevails on the more readily susceptible meromes of the integument.

The development of secondary metameric annulations within the area of a complete somite is not recorded among Arthropoda. It deserves distinct recognition as "hypo-metamerism" or formation of "somatidia."

The last law of metamerism which we shall attempt to formulate here, as the THIRTEENTH, relates to the fusion or blending of neighbouring somites. There are without doubt a large number of important generalizations, to be arrived at hereafter from the further study of the metamerism of Vertebrata and the peculiar phenomena exhibited by the dislocated meromes of the vertebrate's somites. But this is not the place in which to attempt an outline of the special laws of vertebrate metamerism. Fusion of adjacent somites has often been erroneously interpreted in the study of Arthropoda. There are, in fact, very varying degrees of fusion which need to be carefully distinguished. The following generalization may be formulated. "The homologous meromes of two or more adjacent somites tend to fuse with one another by a blending of their substance. Very generally, but not invariably, the fused meromes are found as distinct separated structures in the embryo of the animal, in which they unite at a later stage of growth." The fusion of neighbouring meromes is often preceded by more or less extensive atrophy of the somites concerned, and by arrest of development in the individual ontogeny. Thus, a case of fusion of partially atrophied somites may simulate the appearance of incipient merogenesis or formation of new somites, and, *vice versâ*, incipient merogenesis may be misinterpreted as a case of fusion of once separate and fully-formed somites. Moreover, the two phenomena, merogenesis and fusion of meromes, actually occur side by side in some cases as in the pygidial shields of the Trilobitæ and Limulus.

The most commonly-noted cases of fusion of metameres are simply cases of the fusion of the tegumentary meromes—usually the terga only. Such a fusion has really very serious morphological importance, although superficial and readily acquired. It amounts to no more than the disposition of chitinous cuticle of equal thickness over the area of the terga of the somites concerned instead of the thinning of the cuticular deposit at the adjacent borders of the somites. The somites consequently lose their hinge; they can no longer be flexed one on the other. Atrophy of the muscles related to such flexure necessarily follows. The mesosomatic portion of the posterior carapace of Limulus is no more than such a superficial fusion: the other meromes of the ankylosed somites (appendages, neuromeres, blood-vessels, &c.) are unaffected. Such, too, is the case with the pygidial shields of many Trilobites. On the other hand, the telson, which is joined in both these cases with the superficially fused segments by a fusion of its chitinous cuticle with that of its last-formed or budded somite, can only take part in the fusion as a result of arrest in its activity, which amounts to a late supervening atrophy. This arrest of the telson's special bud-growth may take place very early, in which case we get a large telsonic shield and only a very few somites in front of it—none soldered to the telson as in Agnostus and Illenus; or it may take place later when eight post-cephalic (opisthosomatic) somites have been formed as in Limulus—the last two incompletely. Or, again, thirty or more somites may have been produced before the arrest takes place and fifteen of these may be ankylosed with the telson to form the pygidial shield (Phacops, &c.).

A more complete fusion of somites is that seen in the head of Arthropoda. The head or prosoma of Arthropoda is a tagma consisting of one, two, or three prosthomeres or somites in front of the mouth and of one, two, three, up to five or six opisthomeres. The cephalic tagma or prosoma may thus be more or less sharply divided into two subtagmata, the præ-oral and the post-oral.

The shifting of the mouth backwards in Arthropoda so as to allow segments which once were post-oral to take up a præ-oral position, as prosthomeres, must be regarded as a case of dislocation of the meromes concerned (SIXTH law), like the forward travelling of a fish's pelvic fins. The anus does not appear to be liable to such dislocation in Arthropoda; but it certainly does travel away from its parental metamere in the Vertebrata, and may possibly do so in Chætopods when what must be called "lipomerism" or general obliteration of a metameric ordering of parts sets in. Such "lipomerism" must be supposed to have affected the Chætopod ancestors of the Sipunculids, if those latter worms are to be traced genetically to the former, and the anus has shifted to the anterior third of the body. However that may be, the conception (first put forward by Lankester in 1875, 2) of the backward movement of the mouth in Arthropoda from the first somite to the second, third, or even fourth in the original post-oral series, is not only justified by embryological observation of the shifting in question, but finds its parallel in other instances of the law of dislocation of meromes.

The fusion of the cephalic or prosomatic somites not only extends to tegumentary structures but to muscles, blood-vessels, and markedly to neuromeres. However, in the embryo of many Arthropoda the original neuromeres of the præ-oral somites can be distinguished, and in many cases the cœlomic cavities. Also it is a noteworthy fact that the tegumentary fusion (cephalic carapace, prosomatic carapace) appears sometimes to break down secondarily (*e.g.*, squilla among Crustacea and Galeodes and Tarasside among Arachnida). It appears that we must recognize as a principle that such fusions as the carapaces of Arthropoda can revert to the condition of free movable plates—and therefore we must not assume that forms with fused tergal plates are necessarily later, genetically, than allied forms with free movable tergal plates.

When such reversion to a movable series of dorsal plates occurs it must not be assumed that any corresponding change takes place in the deeper meromes. On the whole, fusion and ankylosis of somites is not in itself necessarily a deep-seated or far-reaching process. It may or may not be accompanied by dislocation of important meromes or by lipomerism; whilst, as for instance in the opisthosoma of the spiders, opiliones and acari, dislocation and lipomerism may occur without *fusion* of tegumentary plates, and with, on the contrary, a dwindling, and eventual atrophy of such plates.

The general considerations as to metamerism set forth above will enable us to proceed to a consideration of the characters which distinguish the various groups of Arthropoda, and to justify the classification with which we started.

The Theory of the Arthropod Head.—The arthropod head is a tagma or group of somites which differ in number and in their relative position in regard to the mouth, in different classes. In a simple Chætopod (Fig. 1) the head consists of the first somite only; that somite is perforated by the mouth, and is provided with a prostomium or præ-oral lobe. The prostomium is essentially a part or outgrowth of the first somite, and cannot be regarded as itself a somite. It gives rise to a nerve-ganglion mass, the prostomial ganglion. In the marine Chætopods (the Polychæta) (Fig. 2), we find the same essential structure, but the prostomium may give rise to two or more tactile tentacles, and to the vesicular eyes. The somites have well-marked parapodia, and the second and third, as well as the first, may give rise to tentacles which are directed forward, and thus contribute to form "the head." But the mouth remains as an inpushing of the wall of the first somite.

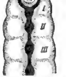


FIG. 1.—Diagram of the head and adjacent region of an Oligochæt Chætopod. *Pr*, the prostomium; *m*, the mouth; *A*, the prostomial ganglion-mass or archi-cerebrum; I, II, III, cœlom of the first, second, and third somites. (From Goodrich, *Q. J. Micr. Sci.* vol. xl. p. 247.)

The Arthropoda are all distinguished from the Chætopoda by the fact that the head consists of one or more somites which lie *in front of the mouth* (now called prosthomeres), as well as of one or more somites behind it (opisthomeres). The first of the post-oral somites invariably has its parapodia modified so as to form a pair of hemignaths (mandibles). Twenty-five years ago the question arose as to whether the somites in front of the mouth are to be considered as derived from the prostomium of a Chætopod-like ancestor. Milne-Edwards and Huxley had satisfied themselves with discussing and establishing, according to the data at their command, the number of somites in the Arthropod head, but had not considered the question of the *nature* of the præ-oral somites. Lankester (2) was the first to suggest that (as is actually the fact in the Nauplius larva of Crustacea) the præ-oral somites or prosthomeres and their appendages were ancestrally post-oral, but have become præ-oral "by adaptational shifting of the oral aperture." This has proved to be a sound hypothesis and is now accepted as the basis upon which the Arthropod head must be interpreted (see Korschelt and Heider (3)). Further, the morphologists of the 'fifties appear, with few exceptions, to have accepted a preliminary scheme with regard to the Arthropod head and Arthropod segmentation generally, which was misleading and caused them to adopt forced conclusions and interpretations. It was conceived by Huxley, among others, that the same number of cephalic somites would be found to be characteristic of all the diverse classes of Arthropoda, and that the somites, not only of the head but of the various regions of the body, could be closely compared in their numerical sequence in classes so distinct as the Hexapods, Crustaceans, and Arachnids.

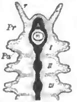


Fig. 2.—Diagram of the head and adjacent region of a Polychæt Chætopod. Letters as in Fig. 1, with the addition of T, prostomial tentacle; *Pa*, parapodium. (From Goodrich.)

The view which it now appears necessary to take is, on the contrary, this—viz., that all the Arthropoda are to be traced to a common ancestor resembling a Chætopod worm, but differing from it in having lost its chætæ and in having a prosthomere in front of the mouth (instead of prostomium only) and a pair of hemignaths (mandibles) on the parapodia of the buccal somite. From this ancestor Arthropods with heads of varying degrees of complexity have been developed characteristic of the different classes, whilst the parapodia and somites of the body have become variously modified and grouped in these different classes. The resemblances which the members of one class often present to the members of another class in regard to the form of the limb-branches (rami) of the parapodia, and the formation of tagmata (regions) are not hastily to be ascribed to common inheritance, but we must consider whether they are not due to homoplasy—that is, to the moulding of natural selection acting in the different classes upon fairly similar elements under like exigencies.

The structure of the head in Arthropods presents *three* profoundly separated grades of structure dependent upon the number of prosthomeres which have been assimilated by the præ-oral region. The classes presenting these distinct plans of head-structure cannot be closely associated in any scheme of classification professing to be natural. Peripatus, the type-genus of the class Onychophora, stands at the base of the series with only a single prosthomere (Fig. 3). In Peripatus the prostomium of the Chætopod-like ancestor is atrophied, but it is possible that two processes on the front of the head (FP) represent in the embryo the dwindled prostomial tentacles. The single prosthomere carries the retractile tentacles as its "parapodia." The second somite is the buccal somite (II, Fig. 3); its parapodia have horny jaws on their ends, like the claws on the following legs (Fig. 8), and act as hemignaths (mandibles). The study of sections of the embryo establishes these facts beyond doubt. It also shows us that the neuromeres, no less than the embryonic cœlomic cavities, point to the existence of one, and only one, prosthomere in Peripatus, of which the "Protocerebrum," P, is the neuromere, whilst the Deuterocerebrum, D, is the neuromere of the second or buccal somite. A brief indication of these facts is given by saying that the Onychophora are "deuterognathous"—that is to say, that the buccal somite carrying the mandibular hemignaths is the second of the whole series.

What has become of the nerve-ganglion of the prostomial lobe of the Chætopod in Peripatus is not clearly ascertained, nor is its fate indicated by the study of the embryonic head of other Arthropods so far. Probably it is fused with the Protocerebrum, and may also be concerned in the history of the very peculiar paired eyes of Peripatus, which are like those of Chætopods in structure—viz., vesicles with an intra-vesicular lens, whereas the eyes of all other Arthropods have essentially another structure, being "cups" of the epidermis, in which a knob-like or rod-like thickening of the cuticle is fitted as refractive medium.

In Diplopoda (*Julus*, &c.) the results of embryological study point to a composition of the front part of the head exactly similar to that which we find in Onychophora. They are deuterognathous.

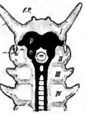


Fig. 3.—Diagram of the head and adjacent region of *Peripatus*. Monoprosthomerous. m, Mouth; I, cœlom of the first somite which carries the antennæ and is in front of the mouth; II, cœlom of the second somite which carries the mandibles (hence deuterognathous); III and IV, cœlom of the third and fourth somites; FP, rudimentary frontal processes perhaps representing the prostomial tentacles of Polychæta; *Ant*, antenna or tactile tentacle; *Md*, mandible; *Op*, oral papilla; P, protocerebrum or foremost cerebral mass belonging to the first somite; D, deuterocerebrum consisting of ganglion cells belonging to the second or mandibular somite. (After Goodrich.)

The Arachnida present the first stage of progress. Here embryology shows that there are two prosthomeres (Fig. 4), and that the gnathobases of the chelæ which act as the first pair of hemignaths, are carried by the third somite. The Arachnida are therefore tritognathous. The two prosthomeres are indicated by their cœlomic cavities in the embryo (I and II, Fig. 4), and by two neuromeres, the Protocerebrum and the Deuterocerebrum. The appendages of the first prosthomere are not present as tentacles, as in Peripatus and Diplopods, but are possibly represented by the eyes or possibly altogether aborted. The appendages of the second prosthomere are the well-known chelicerae of the Arachnida, rarely, if ever, antenniform, but modified as "retroverts" or clasp-knife fangs in spiders.

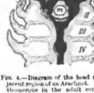


Fig. 4.—Diagram of the head and adjacent region of an Arachnid. Diprosthomerous in the adult condition, though embryologically the appendages of somite II and the somite itself are, as here drawn, not actually in front of the mouth; *E*, lateral eye; *Ch*, chelicera; m, mouth; P, protocerebrum; D, deuterocerebrum; I, II, III, IV, cœlom of the first, second, third, and fourth somites. (After Goodrich.)

The Crustacea (Fig. 5) and the Hexapoda (Fig. 6) agree in having three somites in front of the mouth, and it is probable, though not ascertained, that the Chilopoda (Scolopendra, &c.) are in the same case. The three prosthomeres or præ-oral somites of Crustacea due to the sinking back of the mouth one somite farther than in Arachnida are not clearly indicated by cœlomic cavities in the embryo, but their existence is clearly established by the development and position of the appendages and by the neuromeres.

The eyes in some Crustacea are mounted on articulated stalks, and from the fact that they can after injury be replaced by antenna-like appendages, it is inferred that they represent the parapodia of the most anterior prosthomere. The second prosthomere carries the first pair of antennæ and the third the second pair of antennæ. Sometimes this pair of appendages has not a merely tactile jointed ramus, but is converted into a claw or clasper. Three neuromeres—a proto-, deutero-, and tritocerebrum—corresponding to those three prosthomeres are sharply marked in the embryo. The fourth somite is that in which the mouth now opens, and which accordingly has its appendages converted into hemignathous mandibles. The Crustacea are tetartognathous.

The history of the development of the head has been carefully worked out in the Hexapod insects. As in Crustacea and Arachnida, a first prosthomere is indicated by the paired eyes and the protocerebrum; the second prosthomere has a well-marked cœlomic cavity, carries the antennæ, and has the deuterocerebrum for its neuromere. The third prosthomere is represented by a well-marked pair of cœlomic cavities and the tritocerebrum (III, Fig. 6), but has no appendages. They appear to have aborted. The existence of this third prosthomere corresponding to the third prosthomere of the Crustacea is a strong argument for the derivation of the Hexapoda, and with them the Chilopoda, from some offshoot of the Crustacean stem or class. The buccal somite, with its mandibles, is in Hexapoda, as in Crustacea, the fourth: they are tetartognathous.

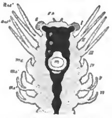


FIG. 5.—Diagram of the head of a Crustacean. Triprosthomerous. *FP*, frontal processes (observed in Cirriped nauplius-larvæ) probably representing the prostomial tentacles of Chætopods; *e*, eye; Ant^1, first pair of antennæ; Ant^2, second pair of antennæ; *md*, mandible; mx^1, mx^2, first and second pairs of maxillæ; *m*, mouth; I, II, and III, the three prosthomeres; IV, V, VI, the three somites following the mouth; P, protocerebrum; D, deuterocerebrum; T, tritocerebrum. (After Goodrich.)

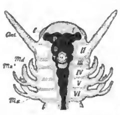


FIG. 6.—Diagram of the head of a Hexapod insect. *e*, eye; *ant*, antenna; *md*, mandible; mx^1, first maxilla; mx^2, second maxilla; *m*, mouth; I, region of the first or eye-bearing prosthomere; II, cœlom of the second antenna-bearing prosthomere; III, cœlom of the third prosthomere devoid of appendages; IV, V, and VI, cœlom of the fourth, fifth, and sixth somites; P, protocerebrum belonging to the first prosthomere; D, deuterocerebrum belonging to the second prosthomere; T, tritocerebrum belonging to the third prosthomere. (After Goodrich.)

The adhesion of a greater or less number of somites to the buccal somite posteriorly (opisthomeres) is a matter of importance, but of minor importance, in the theory and history of the Arthropod head. In Peripatus no such adhesion or fusion occurs. In Diplopoda two opisthomeres—that is to say, one in addition to the buccal somite—are united by a fusion of their terga with the terga of the prosthomeres. Their appendages are respectively the mandibles and the gnathochilarium.

In Arachnida the highest forms exhibit a fusion of the tergites of five post-oral somites to form one continuous carapace united with the terga of the two prosthomeres. The five pairs of appendages of the post-oral somites of the head or prosoma thus constituted all primitively carry gnathobasic projections on their coxal joints, which act as hemignaths: in the more specialized forms the mandibular gnathobases cease to develop.

In Crustacea the fourth or mandibular somite never has less than the two following somites associated with it by the adaptation of their appendages as jaws, and the ankylosis of their terga with that of the prosthomeres. But in higher Crustacea the cephalic "tagma" is extended, and more somites are added to the fusion, and their appendages adapted as jaws of a kind.

The Hexapoda are not known to us in their earlier or more primitive manifestations; we only know them as possessed of a definite number of somites arranged in definite numbers in three great tagmata. The head shows two jaw-bearing somites besides the mandibular somite (V, VI, in Fig. 6)—thus six in all (as in some Crustacea), including prosthomeres, all ankylosed by their terga to form a cephalic shield. There is, however, good embryological evidence in some Hexapods of the existence of a seventh somite, the supra-lingual, occurring between the somite of the mandibles and the somite of the first maxillæ (4). This segment is indicated embryologically by its paired cœlomic cavities. It is practically an excalated somite, having no existence in the adult. It is probably not a mere coincidence that the Hexapod, with its two rudimentary somites devoid of appendages, is thus found to possess twenty-one somites, including that which carries the anus, and that this is also the number present in the Malacostracous Crustacea.

The Segmental Lateral Appendages or Limbs of Arthropoda.—It has taken some time to obtain any general acceptance of the view that the parapodia of the Chætopoda and the limbs of Arthropoda are genetically identical structures; yet if we compare the parapodium of Tomopteris or of Phyllodoce with one of the foliaceous limbs of Branchipus or Apus, the correspondences of the two are striking. An erroneous view of the fundamental morphology of the Crustacean limb, and consequently of that of other Arthropoda, came into favour owing to the acceptance of the highly modified limbs of Astacus as typical. Protopodite, endopodite, exopodite, and epipodite were considered to be the morphological units of the crustacean limb. Lankester (5) has shown (and his views have been accepted by Professors Korschelt and Heider in their treatise on *Embryology*) that the limb of the lowest Crustacea, such as Apus, consists of a corm or axis which may be jointed, and gives rise to outgrowths, either leaf-like or filiform, on its inner and outer margins (endites and exites). Such a corm (see Figs. 9 and 10), with its outgrowths, may be compared to the simple parapodia of Chætopoda with cirrhi and branchial lobe (Fig. 7). It is by the specialization of two "endites" that the endopodite and exopodite of higher Crustacea are formed, whilst a flabelliform exite is the homogen or genetic equivalent of the epipodite (see Lankester, "Observations and Reflections on Apus Cancriformis," *Q. J. Micr. Sci.*). The reduction of the outgrowth-bearing "corm" of the parapodium of either a Chætopod or an Arthropod to a simple cylindrical stump, devoid of outgrowths, is brought about when mechanical conditions favour such a shape. We see it in certain

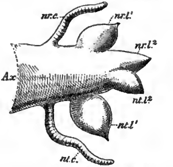


FIG. 7.—Diagram of the somite-appendage or parapodium of a Polychæt Chætopod. The chætæ are omitted. *Ax*, the axis; *nr.c*, neuropodial cirrhus; $nr.l^1$, $nr.l^2$, neuropodial lobes or endites; *nt.c*, notopodial cirrhus; $nt.l^1$, $nt.l^2$, notopodial lobes or exites. The parapodium is represented with its neural or ventral surface uppermost. Original.

Chætopods (*e.g.*, Hesione) and in the Arthropod Peripatus (Fig. 8). The conversion of the Arthropod's limb into a jaw, as a rule, is effected by the development of an endite near its base into a hard, chitinized, and often toothed gnathobase (see Figs. 9 and 10, en^1). It is not true that all the biting processes of the Arthropod limb are thus produced—for instance, the jaws of Peripatus are formed by the axis or corm itself, whilst the poison-jaws of Chilopods, as also their maxillæ, appear to be formed rather by the apex or terminal region of the ramus of the limb; but the opposing jaws (= hemignaths) of Crustacea, Arachnida, and Hexapoda are gnathobases, and not the axis or corm. The endopodite (corresponding to the fifth endite of the limb of Apus, see Fig. 9) becomes in Crustacea the "walking leg" of the mid-region of the body; it becomes the palp or jointed process of anterior segments. A second ramus, the "exopodite," often is also retained in the form of a palp or feeler. In Apus, as the figure shows, there are four of these "antenna-like" palps or filaments on the first thoracic limb. A common modification of the chief ramus of the Arthropod parapodium is the chela or nipper formed by the elongation of the penultimate joint of the ramus, so that the last joint works on it—as, for instance, in the lobster's claw. Such chelate rami or limb-branches are independently developed in Crustacea and in Arachnida, and are carried by somites of the body which do not correspond in position in the two groups. The range of modification of which the rami or limb-branches of the limbs of Arthropoda are capable is very large, and in allied orders or even families or genera we often find what is certainly the palp of the same appendage (as determined by numerical position of the segments)—in one case antenniform, in another chelate, in another pediform, and in another reduced to a mere stump or absent altogether. Very probably the power which the appendage of a given segment has of assuming the perfected form and proportions previously attained by the appendage of another segment must be classed as an instance of "homœosis," not only where such a change is obviously due to abnormal development or injury, but also where it constitutes a difference permanently established between allied orders or smaller groups, or between the two sexes.

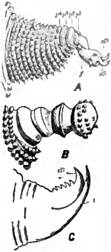


FIG. 8.—Three somite-appendages or parapodia of *Peripatus*. A, a walking leg: p^1 to p^4, the characteristic "pads": *f*, the foot; cl^1, cl^2, the two claws. B, an oral papilla, one of the second pair of post-oral appendages. C, one of the first post-oral pair of appendages or mandibles; cl^1, cl^2, the greatly enlarged claws. (Compare A.) The appendages are represented with the neural or ventral surface uppermost. Original.

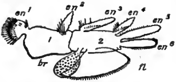


FIG. 9.—The second thoracic (fifth post-oral) appendage of the left side of *Apus cancriformis*, placed with its ventral or neural surface uppermost to compare with Figs. 7 and 8. 1, 2, The two segments of the axis; en^1, the gnathobase; en^2 to en^6, the five following "endites"; *fl*, the flabellum or anterior exite; *br*, the bract or posterior exite. (After Lankester, *Q. J. Mic. Sci.* vol. xxi. 1881.)

The most extreme disguise assumed by the Arthropod parapodium or appendage is that of becoming a mere stalk supporting an eye—a fact which did not obtain general credence until the experiments of Herbst in 1895, who found, on cutting off the eye-stalk of Palæmon, that a jointed antenna-like appendage was regenerated in its place. Since the eye-stalks of Podopthalmate Crustacea represent appendages, we are forced to the conclusion that the sessile eyes of other Crustacea and of other Arthropoda generally, indicate the position of appendages which have atrophied.[1]

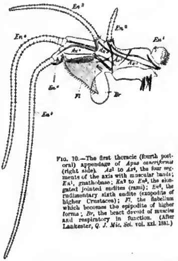


FIG. 10.—The first thoracic (fourth post-oral) appendage of *Apus cancriformis* (right side). Ax^1 to Ax^4, the four segments of the axis with muscular bands; En^1, gnathobase; En^2 to En^5, the elongated jointed endites (rami); En^6, the rudimentary sixth endite (exopodite of higher Crustacea); *Fl*, the flabellum which becomes the epipodite of higher forms; *Br*, the bract devoid of muscles and respiratory in function. (After Lankester, *Q. J. Mic. Sci.* vol. xxi. 1881.)

From what has been said, it is apparent that we cannot, in attempting to discover the affinities and divergences of the various forms of Arthropoda, attach a very high phylogenetic value to the coincidence or divergence in form of the appendages belonging to the somites compared with one another.

The principal forms assumed by the Arthropod parapodium and its rami may be thus enumerated:—

(1) Axial corm well developed, unsegmented or with two to four segments; lateral endites and exites (rami) numerous and of various lengths (certain limbs of lower Crustacea).

(2) Corm, with short unsegmented rami, forming a flattened foliaceous appendage, adapted to swimming and respiration (trunk-limbs of Phyllopods).

(3) Corm alone developed; with no endites or exites, but provided with terminal chitinous claws (ordinary leg of Peripatus), with terminal jaw teeth (jaw of Peripatus), or with blunt extremity (oral papilla of same) (see Fig. 8).

(4) Three of the rami of the primitive limb (endites 5 and 6, and exite 1) specially developed as endopodite, exopodite, and epipodite—the first two often as firm and strongly chitinized, segmented, leg-like structures; the original axis or corm reduced to a basal piece, with or without a distinct gnathobase (endite 1)—typical tri-ramose limb of higher Crustacea.

---

[1] H. Milne-Edwards, who was followed by Huxley, long ago formulated the conclusion that the eye-stalks of Crustacea are modified appendages, basing his argument on a specimen of Palinurus (figured in Bateson's book (1), in which the eye-stalk of one side is replaced by an antenniform palp. Hofer (6) in 1894 described a similar case in Astacus.

(5) One ramus (the endopodite) alone developed—the original axis or corm serving as its basal joint with or without gnathobase. This is the usual uni-ramose limb found in the various classes of Arthropoda. It varies as to the presence or absence of the jaw-process and as to the stoutness of the segments of the ramus, their number (frequently six, plus the basal corm), and the modification of the free end. This may be filiform or brush-like or lamellate when it is an antenna or palp; a simple spike (walking leg of Crustacea, of other aquatic forms, and of Chilopods and Diplopods); the terminal joint flattened (swimming leg of Crustacea and Gigantostraca); the terminal joint provided with two or with three recurved claws (walking leg of many terrestrial forms—*e.g.*, Hexapoda and Arachnida); the penultimate joint with a process equal in length to the last joint, so as to form a nipping organ (chelæ of Crustaceans and Arachnids); the last joint reflected and movable on the penultimate, as the blade of a clasp-knife on its handle (the retrovert, toothed so as to act as a biting jaw in the Hexapod *Mantis*, the Crustacean *Squilla*, and others; with the last joint produced into a needle-like stabbing process in spiders).

(6) Two rami developed (usually, but perhaps not always, the equivalents of the endopodite and exopodite) supported on the somewhat elongated corm (basal segment). This is the typical "biramose limb" often found in Crustacea. The rami may be flattened for swimming, when it is "a biramose swimmeret," or both or only one may be filiform and finely annulate; this is the form often presented by the antennæ of Crustacea, and rarely by præ-oral appendages in other Arthropods.

(7) The endopoditic ramus is greatly enlarged and flattened, without or with only one jointing, the corm (basal segment) is evanescent; often the plate-like endopodites of a pair of such appendages unite in the middle line with one another or by the intermediary of a sternal up-growth and form a single broad plate. (These are the plate-like swimmerets and opercula of Gigantostraca and Limulus among Arachnids and of Isopod Crustaceans. They may have rudimentary exopodites, and may or may not have branchial filaments or lamellæ developed on their posterior faces. The simplest form to which they may be reduced is seen in the genital operculum of the Scorpion).

(8) The gnathobase becomes greatly enlarged and not separated by a joint from the corm; it acts as a hemignath or half-jaw working against its fellow of the opposite side. The endopodite may be retained as a small segmented palp at the side of the gnathobase or disappear (mandible of Crustacea, Chilopoda, and Hexapoda).

(9) The corm becomes the seat of a development of a special visual organ, the Arthropod eye (as opposed to the Chætopod eye). Its jointing (segmentation) may be retained, but its rami disappear (Podophthalmous Crustacea). Usually it becomes atrophied, leaving the eye as a sessile organ upon the præ-oral region of the body. (The eye-stalk and sessile lateral eyes of Arthropoda generally, exclusive of Peripatus).

(10) The forms assumed by special modification of the elements of the parapodium in the maxillæ, labium, &c., of Hexapods, Chilopods, Diplopods, and of various Crustacea, deserve special enumeration, but cannot be dealt with without ample space and illustration.

It may be pointed out that the most radical difference presented in this list is that between appendages consisting of the corm alone without rami (Onychophora) and those with more or less developed rami (the rest of the Arthropoda). In the latter class we should distinguish three phases: (*a*) those with numerous and comparatively undeveloped rami; (*b*) those with three, or two highly developed rami, or with only one—the corm being reduced to the dimensions of a mere basal segment; (*c*) those reduced to a secondary simplicity (degeneration) by overwhelming development of one segment (*e.g.*, the isolated gnathobase often seen as "mandible" and the genital operculum).

There is no reason to suppose that any of the forms of limb observed in Arthropoda may not have been independently developed in two or more separate diverging lines of descent.

Branchiæ.—In connexion with the discussion of the limbs of Arthropods, a few words should be devoted to the gill-processes. It seems probable that there are branchial plumes or filaments in some Arthropoda (some Crustacea) which can be identified with the distinct branchial organs of Chætopoda, which lie dorsad of the parapodia and are not part of the parapodium. On the other hand, we cannot refuse to admit that any of the processes of an Arthropod parapodium may become modified as branchial organs, and that, as a rule, branchial out-growths are easily developed, *de novo*, in all the higher groups of animals. Therefore, it seems to be, with our present knowledge, a hopeless task to analyse the branchial organs of Arthropoda and to identify them genetically in groups.

A brief notice must suffice of the structure and history of the *Eyes*, the *Tracheæ*, and the so-called *Malpighian tubes* of Arthropoda, though special importance attaches to each in regard to the determination of the affinities of the various animals included in this great sub-phylum.

The Eyes.—The Arthropod eye appears to be an organ of special character developed in the common ancestor of the Euarthropoda, and distinct from the Chætopod eye, which is found only in the Onychophora where the true Arthropod eye is absent. The essential difference between these two kinds of eye appears to be that the Chætopod eye (in its higher developments) is a vesicle enclosing the lens, whereas the Arthropod eye is a pit or series of pits into which the heavy chitinous cuticle dips and enlarges knob-wise as a lens. Two distinct forms of the Arthropod eye are observed—the monomeniscous (simple) and the polymeniscous (compound). The nerve-end-cells, which lie below the lens, are part of the general epidermis. They show in the monomeniscous eye (see article ARACHNIDA, Fig. 26) a tendency to group themselves into "retinulæ," consisting of five to twelve cells united by vertical deposits of chitin (rhabdoms). In the case of the polymeniscous eye (Fig. 23, article ARACHNIDA) a single retinula or group of nerve-end-cells is grouped beneath each associated lens. A further complication occurs in each of these two classes of eye. The monomeniscous eye is rarely provided with a single layer of cells beneath its lens; when it is so, it is called monostichous (simple lateral eye of Scorpion, Fig. 22, article ARACHNIDA). More usually, by an infolding of the layer of cells in development, we get three layers under the lens; the front layer is the corneagen layer, and is separated by a membrane from the other two which, more or less, fuse and contain the nerve-end-cells (retinal layer). These eyes are called diplostichous, and occur in Arachnida and Hexapoda (Fig. 24, in article ARACHNIDA).

On the other hand, the polymeniscous eye undergoes special elaboration on its lines. The retinulæ become elongated as deep and very narrow pits (Fig. 11 and explanation), and develop additional cells near the mouth of the narrow pit. Those nearest to the lens are the corneagen cells of this more elaborated eye, and those between the original retinula cells and the corneagen cells become firm and transparent. They are the crystalline cells or vitrella (see Watase, 7). Each such complex of cells underlying the lenticle of a compound eye is called an "ommatidium"; the entire mass of cells underlying a monomeniscous eye is an "ommatæum." The ommatæum, as already stated, tends to segregate into retinulæ which correspond potentially each to an ommatidium of the compound eye. The ommatidium is from the first segregate and consists of few cells. The compound eye

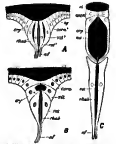


FIG. 11.—Diagram to show the derivation of the unit or "ommatidium" of the compound eye of Crustacea and Hexapoda, C, from a simple monomeniscous monostichous eye resembling the lateral eye of a Scorpion, A, or the unit of the compound lateral eye of Limulus (see article ARACHNIDA, Figs. 22 and 23). B represents an intermediate hypothetical form in which the cells beneath the lens are beginning to be superimposed as corneagen, vitrella, and retinula, instead of standing side by side in horizontal series. The black represents the cuticular product of the epidermal cells of the ocular area, taking the form either of lens, *cl*, of crystalline body, *cry*, or of rhabdom, *rhab*; *hy*, hypodermis or epidermal cells; *corn*¹, laterally-placed cells in the simpler stage, A, which like the nerve-end cells, *vit*¹ and *ret*¹, are corneagens or lens-producing; *corn*, specialized corneagen or lens-producing cells; *vit*¹, potential vitrella cells with *cry*¹, potential crystalline body now indistinguishable from retinula cells and rhabdomeres; *vit*, vitrella cell with *cry*, its contained cuticular product, the crystalline cone or body; *ret*¹, *rhab*¹, retinula cells and rhabdom of scorpion undifferentiated from adjacent cells, *vit*¹; *ret*, retinula cell; *rhab*, rhabdom; *nf*, optic nerve-fibres. (Modified from Watase.)

of the King-Crab (Limulus) is the only recognized instance of ommatidia in their simplest state. Each can be readily compared with the single-layered lateral eye of the Scorpion. In Crustacea and Hexapoda of all grades we find compound eyes with the more complicated ommatidia described above. We do not find them in any Arachnida.

It is difficult in the absence of more detailed knowledge as to the eyes of Chilopoda and Diplopoda to give full value to these facts in tracing the affinities of the various classes of Arthropoda. But they seem to point to a community of origin of Hexapoda and Crustacea in regard to the complicated ommatidia of the compound eye, and to a certain isolation of the Arachnida, which are, however, traceable, so far as the eyes are concerned, to a distant common origin with Crustacea and Hexapoda through the very simple compound eyes (monostichous, polymeniscous) of Limulus.

The Tracheæ.—In regard to tracheæ the very natural tendency of zoologists has been until lately to consider them as having once developed and once only, and therefore to hold that a group "Tracheata" should be recognized, including all tracheate Arthropods. We are driven by the conclusions arrived at as to the derivation of the Arachnida from branchiate ancestors, independently of the other tracheate Arthropods (see article ARACHNIDA), to formulate the conclusion that tracheæ have been independently developed in the Arachnidan class. We are also, by the isolation of Peripatus and the impossibility of tracing to it all other tracheate Arthropoda, or of regarding it as a degenerate offset from some one of the tracheate classes, forced to the conclusion that the tracheæ of the Onychophora have been independently acquired. Having accepted these two conclusions, we formulate the generalization that tracheæ can be independently acquired by various branches of Arthropod descent in adaptation to a terrestrial as opposed to an aquatic mode of life. A great point of interest therefore exists in the knowledge of the structure and embryology of tracheæ in the different groups. It must be confessed that we have not such full knowledge on this head as could be wished for. Tracheæ are essentially tubes like blood-vessels—apparently formed from the same tissue elements as blood-vessels—which contain air in place of blood, and usually communicate by definite orifices, the tracheal stigmata, with the atmosphere. They are lined internally by a cuticular deposit of chitin. In Peripatus and the Diplopods they consist of bunches of fine tubes which do not branch but diverge from one another; the chitinous lining is smooth. In the Hexapods and Chilopods, and the Arachnids (usually), they form tree-like branching structures, and their finest branches are finer than any blood-capillary, actually in some cases penetrating a single cell and supplying it with gaseous oxygen. In these forms the chitinous lining of the tubes is thickened by a close-set spiral ridge similar to the spiral thickening of the cellulose wall of the spiral vessels of plants. It is a noteworthy fact that other tubes in these same terrestrial Arthropoda—namely, the ducts of glands—are similarly strengthened by a chitinous cuticle, and that a spiral or annular thickening of the cuticle is developed in them also. Chitin is *not* exclusively an ectodermal product, but occurs also in cartilaginous skeletal plates of mesoblastic origin (connective tissue). The immediate cavities or pits into which the tracheal stigmata open appear to be in many cases ectodermic in sinkings, but there seems to be no reason (based on embryological observation) for regarding the tracheæ as an ingrowth of the ectoderm. They appear, in fact, to be an air-holding modification of the vasifactive connective tissue. Tracheæ are abundant just in proportion as blood-vessels become suppressed. They are reciprocally exclusive. It seems not improbable that they are two modifications of the same tissue-elements. In Peripatus the stigmatic pits at which the tracheæ communicate with the atmosphere are scattered and not definite in their position. In other cases the stigmata are definitely paired and placed in a few segments or in several. It seems that we have to suppose that the vasifactive tissue of Arthropoda can readily take the form of air-holding instead of blood-holding tubes, and that this somewhat startling change in its character has taken place independently in several instances—viz., in the Onychophora, in more than one group of Arachnida, in Diplopoda, and, again, in the Hexapoda and Chilopoda.

The Malpighian Tubes.—This name is applied to the numerous fine cæcal tubes of noticeable length developed from the proctodæal invert of ectodermal origin in Hexapods. These tubes are shown to excrete nitrogenous waste products similar to uric acid. Tubes of renal excretory function in a like position occur in most terrestrial Arthropoda—viz., in Chilopoda, Diplopoda, and Arachnida. They are also found in some of the semi-terrestrial and purely aquatic Amphipod Crustaceans. But the conclusion that all such tubes are identical in essential character seems to be without foundation. The Malpighian tubes of Hexapods are outgrowths of the proctodæum, but those of Scorpion and the Amphipod Crustacea are part of the metenteron or endodermal gut, though originating near its junction with the proctodæum. Hence the presence or absence of such tubes cannot be used as an argument as to affinity without some discrimination. The Scorpion's so-called Malpighian tubes are *not* the same organs as those so named in the other Tracheata. Such renal cæcal tubes seem to be readily evolved from either metenteron or proctodæum when the conditions of the out-wash of nitrogenous waste-products are changed by the transference from aquatic to terrestrial life. The absence of such renal cæca in Limulus and their presence in the terrestrial Arachnida is precisely on a parallel with their absence in aquatic Crustacea and their presence in the feebly branchiate Amphipoda.

We shall now pass the groups of the Arthropoda in review, attempting to characterize them in such a way as will indicate their probable affinities and genetic history.

SUB-PHYLUM ARTHROPODA.—The characters of the sub-phylum and those of the associated sub-phyla Chætopoda and Rotifera, have been given above, as well as the general characters of the phylum Appendiculata which comprises these great sub-phyla.

Grade A.—**Hyparthropoda.**

Hypothetical forms.

Grade B.—**Protarthropoda.**

(*a*) The integument is covered by a delicate soft cuticle (not firm or plated) which allows the body and its appendages great range of extension and contraction.

(*b*) The paired claws on the ends of the parapodia and the fang-like modifications of these on the first post-oral appendages (mandibles) are the only hard chitinous portions of the integument.

(*c*) The head is deuterognathous—that is to say, there is only one prosthomere, and accordingly the first and only pair of hemignaths is developed by adaptation of the appendages of the second somite.

(*d*) The appendages of the third somite (second post-oral) are clawless oral papillæ.

(*e*) The rest of the somites carry equi-formal simple appendages, consisting of a corm or axis tipped with two chitinous claws and devoid of rami.

(*f*) The segmentation of the body is anomomeristic, there being no fixed number of somites characterizing all the forms included.

(*g*) The pair of eyes situated on the prosthomere are not of the Enarthropod type, but resemble those of Chætopoda (hence Nereid-ophthalmous).

(*h*) The muscles of the body-wall and gut do not consist of transversely-striped muscular fibre, but of the unstriped tissue observed also in Chætopoda.

(*i*) A pair of cœlomoducts is developed in every somite including the prosthomere, in which alone it atrophies in later development.

(*j*) The ventral nerve-cords are widely separated—in fact, lateral in position.

(*k*) There are no masses of nerve-cells forming a ganglion (neuromere) in each somite. (In this respect the Protarthropoda are at a lower stage than most of the existing Chætopoda.)

(*l*) The genital ducts are formed by the enlargement of the cœlomoducts of the penultimate somite.

Class (Unica).—ONYCHOPHORA.

With the characters of the grade: add the presence within the body of fine unbranched tracheal tubes, devoid of spiral thickening, opening to the exterior by numerous irregularly scattered tracheal pits.

Genera—Eoperipatus, Peripatopsis, Opisthopatus, &c.

Grade C (of the Arthropoda).—**Euarthropoda.**

(*a*) Integument heavily plated with firm chitinous cuticle, allowing no expansion and retraction of regions of the body nor change of dimensions, except, in some cases, a dorso-ventral bellows movement. The separation of the heavier plates of chitin by grooves of delicate cuticle results in the hinging or jointing of the body and its appendages, and the consequent flexing and extending of the jointed pieces.

(*b*) Claws and fangs are developed on the branches or rami of the parapodia, not on the end of the axis or corm.

(*c*) The head is either deuterognathous, tritognathous, or tetartognathous.

(*d*) Rarely only one, and usually at least two, of the somites following the mandibular somite carry appendages modified as jaws (with exceptions of a secondary origin).

(*e*) The rest of the somites may all carry appendages, or only a limited number may carry appendages. In all cases the appendages primarily develop rami or branches which form the limbs, the primitive axis or corm being reduced and of insignificant size. In the most primitive stock all the post-oral appendages had gnathobasic outgrowths.

(*f*) The segmentation of the body is anomomeristic in the more archaic members of each class, nomomeristic in the higher members.

(*g*) The two eyes of Chætopod structure have disappeared, and are replaced by the Euarthropod eyes.

(*h*) The muscles in all parts of the body consist of striped muscular fibre, never of unstriped muscular tissue.

(*i*) The cœlomoducts are suppressed in most somites, and retained only as the single pair of genital ducts (very rarely more numerous) and in some also as the excretory glands (one or two pairs).

(*j*) The ventral nerve-cords approach one another in the mid-ventral line behind the mouth.

(*k*) The nerve-cells of the ventral nerve cords are segregated as paired ganglia in each somite, often united by meristic dislocation into composite ganglia.

(*l*) The genital ducts may be the cœlomoducts of the penultimate or antepenultimate or adjacent somite, or of a somite placed near the middle of the series, or of a somite far forward in the series.

Class 1 (of the Euarthropoda).—DIPLOPODA.

The head has but one prosthomere (monoprosthomerous), and is accordingly deuterognathous. This carries short-jointed antennæ (in one case biramose) and eyes, the structure and development of which require further elucidation. Only one somite following the first post-oral or mandibular segment has its appendages modified as jaws.

The somites of the body, except in Pauropus, either fuse after early development and form double somites with two pairs of appendages (Julus, &c.), or present legless and leg-bearing somites alternating.

Somites, anomomeristic, from 12 to 150 in the post-cephalic series.

The genital ducts open in the fourth, or between the fourth and fifth post-oral somite.

Terrestrial forms with small-jointed legs formed by adaptation of a single ramus of the appendage. Tracheæ are present.

Note.—The Diplopoda include the Juliformia, the Symphyla (Scolopendrella), and Pauropoda (Pauropus). They were until recently classified with the Chilopoda (Centipedes), with which they have no close affinity, but only a superficial resemblance. (Compare the definition of the class Chilopoda.)

The movement of the legs in Diplopoda is like that of those of Peripatus, of the Phyllopod Crustacea, and of the Parapodia of Chætopoda, symmetrical and identical on the two sides of the body. The legs of Chilopoda move in alternating groups on the two sides of the body. This implies a very much higher development of nerves and muscles in the latter.

Class 2 (of the Euarthropoda).—ARACHNIDA.

Head tritognathous and diprosthomerous—that is to say, with two prosthomeres, the first bearing typical eyes, the second a pair of appendages reduced to a single ramus, which is in more primitive forms antenniform, in higher forms chelate or retrovert. The ancestral stock was panto-gnathobasic—*i.e.*, had a gnathobase or jaw process on every parapodium. As many as six pairs of appendages following the mouth may have an enlarged gnathobase actually functional as a jaw or hemignath, but a ramus is well developed on each of these appendages either as a simple walking leg, a palp, or a chela. In the more primitive forms the appendage of every post-oral somite has a gnathobase and two rami; in higher specialized forms the gnathobases may be atrophied in every appendage, even in the first post-oral.

The more primitive forms are anomomeristic; the higher forms nomomeristic, showing typically three groups or tagmata of six somites each.

The genital apertures are placed on the first somite of the second tagma or mesosoma. Their position is unknown in the more primitive forms. The more primitive forms have branchial respiratory processes developed on a ramus of each of the post-oral appendages. In higher specialized forms these branchial processes become first of all limited to five segments of the mesosoma, then sunk beneath the surface as pulmonary organs, and finally atrophied, their place being taken by a well-developed tracheal system.

A character of great diagnostic value in the more primitive Arachnida is the tendency of the chitinous investment of the tergal surface of the telson to unite during growth with that of the free somites in front of it, so as to form a pygidial shield or posterior carapace, often comprising as many as fifteen somites (Trilobites, Limulus).

A pair of central monomeniscous diplostichous eyes is often present on the head. Lateral eyes also are often present which are monostichous with aggregated lenses (*Limulus*) or with isolated lenses (Scorpio), or are diplostichous with simple lens (*Pedipalpi*, Araneæ, etc.

Class 3 (of the Euarthropoda).—CRUSTACEA.

Head tetartognathous and triprosthomerous—that is to say, with three prosthomeres: the first bearing typical eyes, the second a pair of antenniform appendages (often biramose), the third a pair of appendages usually antenniform, sometimes claw-like. The ancestral stock was (as in the Arachnida) pantognathobasic, that is to say, had a gnathobase or jaw-process on the base of every post-oral appendage.

Besides the first post-oral or mandibular pair, at least two succeeding pairs of appendages are modified as jaws. These have small and insignificant rami, or none at all, a feature in which the Arachnida differ from them. The appendages of four or more additional following somites may be turned upwards towards the mouth and assist in the taking of food.

The more primitive forms (Entomostraca) are anomomeristic, presenting great variety as to number of somites, form of appendages, and tagmatic grouping; the higher forms (Malacostraca) are nomomeristic, showing in front of the telson twenty somites, of which the six hinder carry swimmerets and the five next in front ambulatory limbs. The genital apertures are neither far forward nor far backward in the series of somites, *e.g.*, on the fourteenth post-oral in Apus, on the ninth post-oral in female Astacus and in Cyclops.

With rare exceptions, branchial plates are developed either by modification of a ramus of the limbs or as processes on a ramus, or upon the sides of the body. No tracheate Crustacea are known, but some terrestrial Isopoda develop pulmonary in-sinkings of the integument. A characteristic, comparable in value to that presented by the pygidial shield of Arachnida, is the frequent development of a pair of long appendages by the penultimate somite, which with the telson form a trifid, or, when that is small, a bifid termination to the body.

The lateral eyes of Crustacea are polymeniscous, with highly specialized retinulæ like those of Hexapoda, and unlike the simpler compound lateral eyes of lower Arachnida. Monomeniscous eyes are rarely present, and when present, single, minute, and central in position.

Note.—The Crustacea exhibit a longer and more complete series of forms than any other class of Arthropoda, and may be regarded as preserving the most completely represented line of descent.

Class 4.—CHILOPODA.

Head triprosthomerous[1] and tetartognathous. The two somites following the mandibular or first post-oral or buccal somite carry appendages modified as maxillæ. The fourth post-oral somite has its appendages converted into very large and powerful hemignaths, which are provided with poison-glands. The remaining somites carry single-clawed walking legs, a single pair to each somite. The body is anomomeristic, showing in different genera from 17 (inclusive of the anal and genital) to 175 somites behind that which bears the poison-jaws. No tagmata are developed. The genital ducts open on the penultimate somite.

---

[1] Embryological evidence of this is still wanting. In the other classes of Arthropoda we have more or less complete embryological evidence on the subject. It appears from observation of the embryo that whilst the first prosthomere of Centipedes has its appendages reduced and represented only by eye-patches (as in Arachnida, Crustacea, and Hexapoda), the second has a rudimentary antenna, which disappears, whilst the third carries the permanent antennæ, which accordingly correspond to the second antennæ of Crustacea, and are absent in Hexapoda.

Tracheæ are developed which are dendriform and with spiral thickening of their lining. Their trunks open at paired stigmata placed laterally in each somite of the trunk or in alternate somites. Usually the tracheæ open by paired stigmata placed upon the sides of a greater or less number of the somites, but never quite regularly on alternating somites. At most they are present on all the pedigerous somites excepting the first and the last. In *Scutigera* there are seven unpaired dorsal stigmata, each leading into a sac whence a number of air-holding tubes project into the pericardial blood-sinus.

Renal cæcal tubes (Malpighian tubes) open into the proctodæum.

Class 5.—Hexapoda.

Head shown by its early development to be triprosthomerous and consequently tetartognathous. The first prosthomere has its appendages represented by the compound eyes and a protocerebrum, the second has the antennæ for its appendages and a deutocerebral neuromere, the third has suffered suppression of its appendages (which corresponded to the second pair of antennæ of Crustacea), but has a tritocerebrum and cœlomic chamber. The mandibular somite bears a pair of gnathobasic hemignaths without rami or palps, and is followed by two jaw-bearing somites (maxillary and labial). This enumeration would give six somites in all to the head—three prosthomeres and three opisthomeres. Recent investigations (Folsom, 4) show the existence in the embryo of a præ-maxillary or supra-lingual somite which is suppressed during development. This gives seven somites to the Hexapod's head, the tergites of which are fused to form a cephalic carapace or box. The number is significant, since it agrees with that found in Edriophthalmous Crustacea, and assigns the labium of the Hexapod to the same somite numerically as that which carries the labium-like maxillipedes of those Crustacea.

The somites following the head are strictly nomomeristic and nomotagmic. The first three form the thorax, the appendages of which are the walking legs, tipped with paired claws or ungues (compare the homoplastic claws of Scorpio and Peripatus). Eleven somites follow these, forming the abdominal "tagma," giving thus twenty-one somites in all (as in the higher Crustacea). The somites of the abdomen all may carry rudimentary appendages in the embryo, and some of the hinder somites may retain their appendages in a modified form in adult life. Terminal telescoping of the abdominal somites and excalation may occur in the adult, reducing the obvious abdominal somites to as few as eight. The genital apertures are median and placed far back in the series of somites, viz., the female on the seventh abdominal (seventeenth of the whole series) and the male on the ninth or ante-penultimate abdominal (nineteenth of the whole series). The appendages of the eighth and tenth abdominal somites are modified as gonapophyses. The eleventh abdominal segment is the telson, usually small and soft; it carries the anus.

The Hexapoda are not only all confined to a very definite disposition of the somites, appendages, and apertures, as thus indicated, but in other characters also they present the specialization of a narrowly-limited highly-developed *order* of such a *class* as the Crustacea rather than a range from lower more generalized to higher more specialized forms such as that group and also the Arachnida present. It seems to be a legitimate conclusion that the most primitive Hexapoda were provided with wings, and that the term Pterygota might be used as a synonym of Hexapoda. Many Hexapoda have lost either one pair or both pairs of wings; cases are common of wingless genera allied to ordinary Pterygote genera. Some Hexapods which are very primitive in other respects happen to be also Apterous, but this cannot be held to prove that the possession of wings is not a primitive character of Hexapods (compare the case of the Struthious Birds). The wings of Hexapoda are lateral expansions of the terga of the second and third thoracic somites. They appear to be serial equivalents (homogenous meromes) of the tracheal gills, which develop in a like position on the abdominal segments of some aquatic Hexapods.

The Hexapoda are all provided with a highly developed tracheal system, which presents considerable variation in regard to its stigmata or orifices of communication with the exterior. In some a serial arrangement of stigmata comparable to that observed in Chilopoda is found. In other cases (some larvæ) stigmata are absent; in other cases again a single stigma is developed, as in the smaller Arachnida and Chilopoda, in the median dorsal line or other unexpected position. When the facile tendency of Arthropoda to develop tracheal air-tubes is admitted, it becomes probable that the tracheæ of Hexapods do not all belong to one original system, but may be accounted for by new developments within the group. Whether the primitive tracheal system of Hexapoda was a closed one or open by serial stigmata in every somite remains at present doubtful, but the intimate relation of the system to the wings and tracheal gills cannot be overlooked.

The lateral eyes of Hexapoda, like those of Crustacea, belong to the most specialized type of "compound eye," found only in these two classes. Simple monomeniscous eyes are also present in many Hexapoda.

Renal excretory cæca (Malpighian tubes) are developed from the proctodæum (not from mesenteron as in Scorpion and Amphipoda).

Concluding Remarks on the Relationships to one another of the Classes of the Arthropoda.—Our general conclusion from a survey of the Arthropoda amounts to this, that whilst Peripatus, the Diplopoda, and the Arachnida represent *terrestrial* offshoots from successive lower grades of primitive *aquatic* Arthropoda which are extinct, the Crustacea alone present a fairly full series of representatives leading upwards from unspecialized forms. The latter were not very far removed from the aquatic ancestors (Trilobites) of the Arachnida, but differed essentially from them by the higher specialization of the head. We can gather no indication of the forefathers of the Hexapoda or of the Chilopoda less specialized than they are, whilst possessing the essential characteristics of these classes. Neither embryology nor palæontology assists us in this direction. On the other hand, the facts that the Hexapoda and the Chilopoda have triprosthomerous heads, that the Hexapoda have the same total number of somites as the nomomeristic Crustacea, and the same number of opisthomeres in the head as the more terrestrial Crustacea, together with the same adaptation of the form of important appendages in corresponding somites, and that the compound eyes of both Crustacea and Hexapoda are extremely specialized and elaborate in structure and identical in that structure, all lead to the suggestion that the Hexapoda, and with them, at no distant point, the Chilopoda, have branched off from the Crustacean main stem as specialized terrestrial lines of descent. And it seems probable that in the case of the Hexapoda, at any rate, the point of departure was subsequent to the attainment of the nomomeristic character presented by the higher grade of Crustacea. It is on the whole desirable to recognize such affinities in our schemes of classification. We may tabulate the facts as to head-structure in Chætopoda and Arthropoda as follows:—

Grade *x* (below the Arthropoda).—Agnatha, Aprosthomera.

Without parapodial jaws; without the addition of originally post-oral somites to the præ-oral region, which is a simple prostomial lobe of the first somite; the first somite is perforated by the mouth and its parapodia are not modified as jaws.

=Chætopoda.

Grade 1 (of the Arthropoda).—Monognatha, Monoprosthomera.

With a single pair of parapodial jaws carried by the somite which is perforated by the mouth; this is not the first somite, but the second. The first somite has become a prosthomere, and carries a pair of extensile antennæ.

=Onychophora (*Peripatus, &c.*).

Grade 2 (of the Arthropoda).—Dignatha, Monoprosthomera.

The third somite as well as the second develops a pair of parapodial jaws; the first somite is a prosthomere carrying jointed antennæ.

=Diplopoda.

Grade 3 (of the Arthropoda).—Pantognatha, Diprosthomera.

A gnathobase is developed (in the primitive stock) on every pair of post-oral appendages; two prosthomeres present, the second somite as well as the first having passed in front of the mouth, but only the second has appendages.

=Arachnida.

Grade 4 (of the Arthropoda).—Pantognatha, Triprosthomera.

The original stock, like that of the last grade, has a gnathobase on every post-oral appendage, but three prosthomeres are now present, in consequence of the movement of the oral aperture from the third to the fourth somite. The lateral eyes are polymeniscous, with specialized vitrellæ and retinulæ of a definite type peculiar to this grade.

=Crustacea, Chilopoda,[1] Hexapoda.

According to older views the increase of the number of somites in front of the mouth would have been regarded as a case of intercalation by new somite-budding of new præ-oral somites in the series. We are prohibited by a general consideration of metamerism in the Arthropoda (see a previous section of this article) from adopting the hypothesis of intercalation of somites. However strange it may seem, we have to suppose that one by one in the course of long historical evolution somites have passed forwards and the mouth has passed backwards. In fact, we have to suppose that the actual somite which in grades 1 and 2 bore the mandibles lost those mandibles, developed their rami as tactile organs, and came to occupy a position in front of the mouth, whilst its previous jaw-bearing function was taken up by the next somite in order, into which the oral aperture had passed. A similar history must have been slowly brought about when this second mandibulate somite in its turn became agnathous and passed in front of the mouth. The mandibular parapodia may be supposed during the successive stages of this history to have had, from the first, well-developed rami (one or two) of a palp-like form, so that the change required when the mouth passed away from them would merely consist in the suppression of the gnathobase. The solid palpless mandible such as we now see in some Arthropoda is, necessarily, a late specialization. Moreover, it appears probable that the first somite never had its parapodia modified as jaws, but became a prosthomere with tactile appendages before parapodial jaws were developed at all, or rather *pari passu* with their development on the second somite. It is worth while bearing in mind a second possibility as to the history of the prosthomeres, viz., that the buccal gnathobasic parapodia (the mandibles) were in each of the three grades of prosthomerism only developed after the recession of the mouth and the addition of one, of two, or of three post-oral somites to the præ-oral region had taken place. In fact, we may imagine that the characteristic adaptation of one or more pairs of post-oral parapodia to the purposes of the mouth as jaws did not occur until after ancestral forms with one, with two, and with three prosthomeres had come into existence. On the whole the facts seem to be against this supposition, though we need not suppose that the gnathobase was very large or the rami undeveloped in the buccal parapodia which were destined to lose their mandibular features and pass in front of the mouth.

References.—1. Bateson. *Materials for the Study of Variation* (Macmillan, 1894), p. 85.—2. Lankester. "Primitive Cell-layers of the Embryo," *Annals and Mag. Nat. Hist.* 1873, p. 336.—3. Korschelt and Heider. *Entwickelungsgeschichte* (Jena, 1892), cap. xv. p. 389.—4. Folsom. "Development of the Mouth Parts of Anurida," *Bulletin Mus. Comp. Zool. Harvard College*, vol. xxxvi. No. 5, 1900, pp. 142-146.—5. Lankester. "Observations and Reflections on the Appendages and Nervous System of Apus Cancriformis," *Quart. Journ. Micr. Sci.* vol. xxi. 1881.—6. Hofer. "Ein Krebs mit einer extremität statt eines Stielauges," *Verhandl. d. Deutschen Zool. Gesellsch.* 1894.—7. Watase. "On the Morphology of the Compound Eyes of Arthropods," *Studies from the Biol. Lab. of the Johns Hopkins University*, vol. iv. pp. 287-334.—8. Benham describes backward shifting of the oral aperture in certain Chætopoda. *Proc. Zoolog. Soc. London*, 1900, No. lxiv. p. 976.—*N.B.*—References to the early literature concerning the group Arthropoda will be found in Carus, *Geschichte der Zoologie*. The more important literature up to 1892 is given in the admirable treatise on Embryology by Professors Korschelt and Heider.

(E. R. L.)

Arthur, Chester Alan (1830-1886), twenty-first president of the United States, was born in Fairfield, Vt., 5th October 1830. His father, William Arthur, when eighteen years of age, emigrated from County Antrim, Ireland, and, after teaching in various places in Vermont and Lower Canada, became a Baptist minister. William Arthur had married Malvina Stone, an American girl who lived at the time of the marriage in Canada, and the numerous changes of the family residence afforded a basis for allegations in 1880 that the son Chester was born not in Vermont, but in Canada, and was therefore ineligible for the presidency. Chester entered Union College as a sophomore, and graduated with honour in 1848. He then became a schoolmaster, at the same time studying law. In 1853 he entered a law office in New York City, and in the following year was admitted to the bar. In politics he was actively associated from the outset with the Republican party. When the Civil War began he held the position of engineer-in-chief on Governor Morgan's staff, and afterwards became acting quartermaster-general of the state troops, in which capacity he showed much administrative efficiency. At the close of Governor Morgan's term, 31st December 1862, General Arthur resumed the practice of his profession, remaining active, however, in party politics in New York City. In November 1871 he was appointed collector of customs for the port of New York. The custom-house had long been conspicuous for the most flagrant abuses of the "spoils system"; and though General Arthur admitted that the evils existed and that they rendered efficient administration impossible, he made no extensive reforms. In 1877 President Hayes began the reform of the civil service with the New York custom-house. A non-partisan commission appointed by Secretary Sherman recommended sweeping changes. The president demanded the resignations of Arthur and his two principal subordinates. General Arthur refused, on the ground that to retire "under fire" would be to acknowledge wrong-doing, and claimed that as the abuses were inherent in a widespread system he should not be made to bear the responsibility alone. His cause was espoused by Senator Conkling, for a time successfully; but on 11th July 1878, during a recess of the Senate, the collector was removed, and in January 1879, after another severe struggle, this action received the approval of the Senate. In 1880 General Arthur was a delegate at large from New York to the Republican National Convention. In common with the rest of the "Stalwarts" he worked hard for the nomination of Grant. Upon the triumph of Garfield, the necessity of conciliating the defeated faction led to the hasty acceptance of Arthur for the second place on the ticket. His nomination was coldly received by the public; and when, after his election and accession, he actively engaged on behalf of Conkling in the great conflict with Garfield over the New York patronage, the impression was widespread that he was unworthy of his position. Upon the death of President Garfield, 19th September 1881, Arthur took the oath as his successor. Contrary to the general expectation, his appointments were as a rule unexceptionable, and he earnestly promoted the Pendleton law for the reform of the civil service. His use of the veto in the cases of a Chinese Immigration Bill and a River and Harbour Bill in 1882 confirmed the favourable impression which had been made. His administration was lacking in political situations of a dramatic character, but on all questions that arose his policy was sane and dignified. In 1884 he allowed his name to be presented for renomination in the Republican Convention, but he was easily defeated by the friends of Mr Blaine. At the expiration of his term he resumed his residence in New York City, where he died on 18th November 1886. (W. A. D.)

---

[1] The eyes of Chilopoda are not thoroughly understood, and may or may not be capable of interpretation as fitting in with those of Crustacea and Hexapoda.

Artillery.—Originally this word was applicable not only to missiles in general, but to the instruments or machines from which they were discharged—slings, bows and arrows, *tormenta*, &c. In the following article, however, we shall confine ourselves to the introduction of modern artillery and the progress of the bodies of men attached to its service.

The earliest recipe we possess for gunpowder is that of Dr John Anderne, who began to practise before 1350, and in his old age was appointed surgeon to Henry IV. It was recovered from his MSS. (now among the Sloane papers) by Mr Albert Way, and given in his edition of the *Promptorium Parvulorum*, an English-Latin vocabulary of the year 1440, in a note under "Gunne." This recipe is:—Saltpetre, 66·6′ parts; charcoal, 22·2′ parts; sulphur, 17·7′ parts. The remarkable point about this recipe is, that it is identical with that given for rocket composition in the MS. of Marcus Graecus, who lived long before Friar Roger Bacon; and rocket composition will not project a round shot. The difficulty is easily explained. The fizzing rocket composition prepared with the Greek's impure ingredients became an explosive when prepared with the comparatively pure ingredients of a later age in the same proportions. If Bacon could refine nitre—a matter that hardly admits of a doubt—there may be a substratum of truth in the legend of the destruction of his Brazen Head. He and Friar Bungey, having mixed the pure ingredients in the old proportions, lay down to sleep. Their servant, Miles, from idle curiosity, applied fire to it, and produced an unexpected explosion which broke some of the chemical apparatus and terrified all three of them. If this view of the case be accepted gunpowder was invented by accident. It is not known who invented cannon, and we must fall back on the tradition that assigns the invention to a German monk, one Berthold Schwartz. There is good evidence to show that the Germans used guns at the siege of Cividale in Italy, 1331, and England had guns, both of iron and brass, in her navy in 1338. She was the first nation to bring guns into the open fields (at Cressy). Froissart calls these guns in one place *kanons*, in another *bombardiaulx;* but Anderne expressly says they were called *gonnes* (in England), and Chaucer and Langland apply to them this word which had previously been used to denote the ancient *tormenta*.

For some three and a half centuries after the introduction of cannon artillerymen in all countries were civilians. Matters came to such a pass in England in the middle of the 16th century, that Henry VIII. had to employ Dutch gunners to instruct the men. In the time of Elizabeth the ages of some of the Tower gunners ranged from 64 to 92 years. The first to attempt any organization of the arm was Gustavus Adolphus. This great man clearly saw that the fundamental principle of all artillery organization is a twofold division, the gunners who follow an army into the field, and those who do not—field artillery and garrison artillery, and he reorganized his artillery accordingly; but he does not appear to have taken any step towards making them a military body. When the Great Rebellion broke out, loud were the complaints about the scarcity and insufficiency of the gunners. In 1638, Wemyss, master gunner of England, reported that there were "few gunners in the kingdom . . . who understand the several ranges of ordnance or use of the mortar"; Norton refers in 1643 to "the penury of expert gunners"; and Eldred denounces "the idle laziness of the gunners," for which he had little or no power to punish them. Things became at length so intolerable that a warrant, dated 22nd August 1682, put the gunners under military discipline. Strange to say, the master gunners were shewn as part of the "civil" establishment as late as 24th January 1783, in the establishment warrant of the ordnance. The ordnance officials had now some power over the gunners, yet their position was still so doubtful that a clause had to be inserted in their commissions in 1694 to place it beyond all doubt. These events were followed by the establishment of two permanent companies of artillery, 26th May 1716, and the formation of the (present) Royal Regiment of Artillery, 1st April 1722. Notwithstanding these improvements, Colonel Forbes Macbean, F.R.S., R.A., declares that the English artillery did not begin to assume a military appearance until the Flanders campaigns of 1748-49.

The officers of the French artillery before Louis XIV.'s time were only officers in the sense that they held an office. They were without rank in the army, and had no troops under their command. Only when war broke out were these officials suited and supplied with the necessary *matériel*. At length Vauban protested against their position as helpless civilians, and they received military rank when Vallière reorganized the artillery in 1732.

"When Frederick the Great assumed the crown he found the army in a very good condition, excepting the corps of artillery and engineers, which consisted chiefly of mechanics and artisans, scarcely looked on by the rest of the army and the officers without commissions. His Majesty immediately drafted all the illiterate officers into the garrison regiments, supplying their places with gentlemen of examined capacity; gave them all commissions, rank with the officers of the guards, and an extraordinary pay."[1] It is strange that Capt. Smith, who was inspector of the Royal Military Academy, Woolwich, should have made no reference to the Prussian horse artillery. In 1773 the king formed a depot at Potsdam for the horse artillery (first formed 21st April 1759), consisting of 1 captain, 1 lieutenant, 10 non-commissioned officers, and 60 gunners. It is almost certain His Majesty had no intention of making it a *corps d'élite*.

Owing to the great progress made during the 18th century by those arts and sciences on which the efficiency of artillery essentially depends, it increased rapidly in numbers, and colleges were everywhere founded for the instruction of officers and others. The Royal Military Academy at Woolwich was opened in 1741. With regard to numbers, the four companies England possessed in the early years of the century were represented in Capt. Smith's time by four battalions; and these 3000 to 4000 men had swollen to 42,000 officers and men in 1899. Other artilleries increased in similar proportions.

The organization of the artilleries of the Great Powers is described under "Armies." A few remarks may be offered on the fundamental principles on which all these organizations are more or less based. Before the 18th century only one man can be named, the great Gustavus Adolphus, who clearly understood the first principle of all artillery organization—the separation of the personnel into two distinct bodies: (*a*) those who follow the army into the field, and (*b*) those who do not. This primary division of the artillery has long been practically acknowledged on the Continent and has been partially adopted in England. British garrison artillery consists of two branches: (*a*) the garrison artillery proper, or the gunners who defend a besieged fortress; and (*b*) the siege artillery, or the gunners who attack an enemy's fortress. Occasionally in a battle in the field guns of the 40-pr. type are used, taking up a fixed position which they occupy during the day. Whether these guns of position should be manned by garrison or field artillery is purely an academic question. The various subdivisions of the field artillery arise naturally from the nature of the duties they have to perform; while the nature of the ordnance with which they are severally armed is determined by the axiom, that the proper gun for any duty is the heaviest gun by which it can be carried out. The main body of the field artillery, the field batteries, are intended to support the infantry; and, in order to do so, they must be capable of moving at a trot (and occasionally a gallop), the gunners being carried on the gun-carriages and limber, or the off-horses of the gun-team. Experience shows that guns of the 15-pr. type, drawn by six horses, are the most suitable for this branch. Similarly, guns of the 7-pr. type, carried on mules, are the best adapted for mountain artillery. For years there was much difficulty in organizing a body of field artillery to support cavalry. At length Frederick the Great solved the question by the creation of horse artillery, so called, not because the guns are drawn by horses, but because the gunners accompanying the gun are mounted on horses of their own distinct from the gun-team. At present the British equipment consists of guns of the 12-pr. type, each drawn by six horses.

For some five centuries the word "Artillery" in England meant simply garrison artillery; the field artillery only existed in time of war. When war broke out a train of artillery was organized, consisting of a certain number of field (or siege) guns, manned by garrison gunners; and when peace was proclaimed the train was disbanded, the *matériel* being returned into store, and the gunners reverting to some fort or stronghold. The first permanent body of field artillery in England were A and B troops of the royal horse artillery raised in 1793, the drivers of which (as well as the gunners) were enlisted under the military oath. In the early years of the nineteenth century a separate driver corps, under its own officers, was formed for the field batteries, but it was with good reason disbanded after Waterloo. The first permanent force of field batteries may be dated from the camp at Cobham, 1853. It is impossible to say on what principles the reorganization in 1899 of the artillery was based. This era now consists of two large separate branches: (*a*) the royal horse artillery and the field batteries, and (*b*) the siege artillery, heavy field batteries, garrison artillery proper, and mountain artillery. There are 28 service batteries of horse artillery, armed with 12-pr. B.L. guns; 100 service field batteries armed with 15-pr. B.L. guns; and 12 service field batteries armed with 5-in. B.L. rifled howitzers—in all cases 6 pieces per battery. The formation of the latter was necessitated by the comparative flatness of the 12-pr. and 15-pr. trajectories, and the want of a shell, with a large angle of descent, to act upon troops under cover of earthworks, &c. The officers for each rank of the horse artillery are selected from the field batteries, to which they return on promotion to the next higher rank, a system which gives rise to a constant interchange of officers. The garrison artillery consists of 104 service companies, of 199 officers and men each, on war strength, of which 7 companies are attached to siege train batteries, and 4 to heavy field batteries for Indian service.

---

[1] *Universal Military Dictionary.* Capt. G. Smith, R.A. London, 1779.

A siege train battery for India consists of four 5-in. B.L. guns and two 6-in. B.L. howitzers. For service in South Africa, four 7-in. B.L. guns have been substituted for 6-in. B.L. guns. An Indian heavy field battery is armed with four 30-pr. B.L. guns and two 5·4-in. B.L. howitzers. A mountain battery is armed with six 2·5-in. screw R.M.L. guns, the projectile of which weighs 7 ℔. A 10-pr. gun is under consideration. In addition to the foregoing there are in India 10 mountain batteries armed with 2·5-in. R.M.L. guns, 11 manned by natives, and 4 field batteries of the Haiderabad contingent armed with two 6-pr. S.B. guns and two 12-pr. S.B. howitzers. Finally, there are 13 companies of local artillery; at Kohat, 1 company; at Hong-Kong, 4; at Singapore, 1; in Ceylon, 2; in Mauritius, 2; at Sierra Leone, 1; at Jamaica, 1; and at St Lucia, 1. (H. W. L. H.)

Arts and Crafts.—The arts of decorative design and handicraft are comprehended under this title—all those arts and crafts, it may be said, which, in association with the mother-craft of building (or architecture) go to the making of the house beautiful. Arts and crafts are also associated with the movement generally understood as the English revival of decorative art, which has characterized the years since about 1875. The title itself only came into general use when the Arts and Crafts Exhibition Society was founded, and held its first exhibition at the New Gallery, London, in the autumn of 1888, since which time arts and crafts exhibitions have been common all over Great Britain. The idea of forming a society for the purpose of showing contemporary work in design and handicraft really arose out of a movement of revolt or protest against the exclusive view of art encouraged by the Royal Academy exhibitions, in which oil paintings in gilt frames claimed almost exclusive attention—sculpture, architecture, and the arts of decorative design, being relegated to quite subordinate positions. In 1886, out of a feeling of discontent among artists as to the inadequacy of the Royal Academy exhibitions, considered as representing the art of Great Britain, a demand arose for a national exhibition to include all the arts of design. One of the points of this demand was for the annual election of the hanging committee by the whole body of artists. After many meetings the group representing the arts and crafts (who belonged to a larger body of artists and craftsmen called the Art-workers' Guild, founded in 1884),[1] perceiving that the painters, especially the leading group of a school not hitherto well represented in the Academy exhibitions, only cherished the hope of forcing certain reforms on the Academy, and were by no means prepared to lose their chances of admission to its privileges, still less to run any risk in the establishment of a really comprehensive national exhibition of art, decided to organize an exhibition themselves in which artists and craftsmen might show their productions, so that contemporary work in decorative art should be displayed to the public on the same footing, and with the same advantages as had hitherto been monopolized by pictorial art. For many years previously there had been great activity in the study and revival in the practice of many of the neglected decorative handicrafts. Amateur societies and classes were in existence, like the Home Arts and Industries Association, which had established village classes in wood-carving, metal work, spinning and weaving, needlework, pottery, and basket-work, and the public interest was steadily growing in handicraft. The machine production of an industrial century had laid its iron hands upon what had formerly been the exclusive province of the handicraftsman, who only lingered on in a few obscure trades and in forgotten corners of England for the most part. The ideal of mechanical perfection dominated British workmen, and the factory system, first by extreme division of labour, and then by the further specialization of the workman under machine production, left no room for individual artistic feeling among craftsmen trained and working under such conditions. The demand of the world-market ruled the character and quality of production, and to the few who would seek some humanity, simplicity of construction, or artistic feeling in their domestic decorations and furniture the only choice was that of the tradesman or salesman, or a plunge into costly and doubtful experiments in original design. From the 'forties onward there had been much research and study of mediæval art in England; there had been many able designers, architects, and antiquaries, such as the Pugins and Henry Shaw, and later William Burges, Butterfield, and G. E. Street and others. The school of præ-Raphaelite painters, by their careful and thorough methods, and their sympathy with mediæval design, were among the first to turn attention to beauty of design, colour, and significance in the accessories of daily life, and artists like D. G. Rossetti, Ford Madox Brown, and W. Holman Hunt themselves designed and painted furniture. The most successful and most practical effort indeed towards the revival of sounder ideas of construction and workmanship may be said to have arisen out of the work of this group of artists, and may be traced to the workshop of William Morris and his associates in Queen Square, London. William Morris, whose name covers so large a field of artistic as well as literary and social work, came well equipped to his task of raising the arts of design and handicraft, of changing the taste of his countrymen from the corrupt and vulgar ostentation of the Second Empire, and its cheap imitations, which prevailed in the 'fifties and 'sixties, and of winning them back, for a time at least, to the massive simplicity of plain oak furniture, or the delicate beauty of inlays of choice woods, or the charm of painted work, the richness and frank colour of formal floral and heraldic pattern in silk textiles and wall-hangings and carpets, the gaiety and freshness of printed cotton, or the romantic splendour of arras tapestry. Both William Morris and his artistic comrade and life-long friend, Edward Burne-Jones, were no doubt much influenced at the outset by the imaginative insight, the passionate artistic feeling, and the love of mediæval romance and colour of Dante Gabriel Rossetti, who remains so remarkable a figure in the great artistic and poetic revival of the latter half of the 19th century. To William Morris himself, in his artistic career, it was no small advantage to gain the ear of the English public first by his poetry. His verse-craft helped his handicraft, but both lived side by side. The secret of Morris's great influence in the revival was no doubt to be attributed to his way of personally mastering the working details and handling of each craft he took up in turn, as well as to his power of inspiring his helpers and followers. He was painter, designer, scribe, illuminator, wood-engraver, dyer, weaver, and finally printer and paper-maker, and having mastered these crafts he could effectively direct and criticize the work of others. His own work and that of Burne-Jones were well known to the public, and in high favour long before the Arts and Crafts Exhibition Society was formed, and though largely helped and inspired by the work of these two artists, the aims and objects of the society rather represented those of a younger generation, and were in some measure a fresh development both of the social and the artistic ideas which were represented by Ruskin, Rossetti, and Morris, though the society includes men of different schools. Other sources of influence might be named, such as the work of Norman Shaw and Philip Webb in architecture and decoration, of Lewis Day in surface pattern, and William de Morgan in pottery. The demand for the acknowledgment of the personality of each responsible craftsman in a co-operative work was new, and it had direct bearing upon the social and economic conditions of artistic production. The principle, too, of regarding the material, object, method, and purpose of a work as essential conditions of its artistic expression, the form and character of which must always be controlled by such conditions, had never before been so emphatically stated, though it practically endorsed the somewhat vague aspirations current for the unity of beauty with utility. Again, a very notable return to extreme simplicity of design in furniture and surface decoration may be remarked; and certain reserve in the use of colour and ornament, and a love of abstract forms in decoration generally, which are characteristic of later taste. Not less remarkable has been the new development in the design and workmanship of jewellery, gold- and silver-smiths' work, and enamels, with which the names of Alexander Fisher, Henry Wilson, Nelson Dawson, and C. R. Ashbee are associated. Among the arts and crafts of design which have blossomed into new life in recent years—and there is hardly one which has not been touched by the new spirit — book-binding must be named as having attained a fresh and tasteful development through the work of Mr Cobden-Sanderson and his pupils. The art and craft of the needle also must not be forgotten, and its progress is a good criterion of taste in design, choice of colour, and treatment. The work of Mrs Morris, of Miss Burden (sometime instructress at the Royal School of Art Needlework, which has carried on its work from 1875), of Miss May Morris, of Miss Una Taylor, of Miss Buckle, of Mrs Walter Crane, of Mrs Newbery, besides many other skilled needlewomen, has been frequently exhibited. Good work is often seen in the national competition works of the students of the English art schools, shown at South Kensington in July. The increase of late years in these exhibitions of designs worked out in the actual material for which they were intended is very remarkable, and is an evidence of the spread of the arts and crafts movement (fostered no doubt by the increase of technical schools, especially of the type of the Central School of Arts and Crafts under the Technical Education Board of the London County Council), of which it may be said that if it has not turned all British craftsmen into artists or all British artists into craftsmen, it has done not a little to expand and socialize the idea of art, and (perhaps it is not too much to say) has made the tasteful English house with its furniture and decorations a model for the civilized world. (W. CR.)

---

[1] Whose members, comprehending as they do the principal living designers, architects, painters, and craftsmen of all kinds, have played no inconsiderable part in the aforesaid English revival.

Aru (Dutch *Aroe*) Islands, a group in the Dutch residency of Amboyna, S. of New Guinea, in 5° 18′ to 7° 5′ S. and 134° 8′ to 134° 56′ E. The larger islands (Wokan, Kobrnr, Maikor, and Trangan), and certain of the lesser ones are regarded by the Malays as one land mass which they call *tana besar* ("great land"). Their area is 2442 square miles, not densely populated by about 13,000 inhabitants, of whom 581 are Christians and 409 Mahommedans. The chief town, Dobbo, is visited by steamers of the Royal Steam Packet Company. The natives are governed by rajas (*orang kajas*), the Dutch Government being represented by a *posthouder*.

Aruwimi, R. See CONGO.

Arzamas, a district town of Russia, government and 81 miles S.W. of Nijni Novgorod, on the Tesha river. It is an important centre of trade, and has fifteen tanneries, twenty oil-works, flour-mills, and tallow-melting houses, and knitting is an important domestic industry. Population, 10,591.

Asbjörnsen, Peter Christen (1812-1885), and **Moe, Jörgen Engebretsen** (1813-1882), the eminent collectors of Norwegian folklore, were so closely united in their life's work that it is unusual to name them apart. Asbjörnsen was born in Christiania on the 15th January 1812; he belonged to an ancient family of the Gudbrandsdal, which is believed to have died with him. He became a student at the university in 1833, but as early as 1832, in his twentieth year, he had begun to collect and write down all the fairy stories and legends which he could meet with. Later he began to wander on foot through the length and breadth of Norway, adding to his stores. Moe, who was born at Mo i Hole parsonage, in Ringerike, on the 22nd April 1813, met Asbjörnsen first when he was fourteen years of age. A close friendship began between them, and lasted to the end of their lives. In 1834 Asbjörnsen discovered that Moe had started independently on a search for the relics of national folklore; the friends eagerly compared results, and determined for the future to work in concert. By this time, Asbjörnsen had become by profession a zoologist, and with the aid of the university made a series of investigating voyages along the coasts of Norway, particularly in the Hardanger fjord. Moe, meanwhile, had devoted himself to the study of theology, and was making a living as a tutor in Christiania. In his holidays he wandered through the mountains, in the most remote districts, collecting stories. In 1842-43 appeared the first instalment of the great work of the two friends, under the title of *Norwegian Popular Stories*, which was received at once all over Europe as a most valuable contribution to science as well as literature. A second volume was published in 1844, and a new collection in 1871. In 1845 Asbjörnsen published, without help from Moe, a collection of Norwegian fairy tales (*huldreeventyr og folkesagn*). In 1856 the attention of Asbjörnsen was called to the deforestation of Norway, and he induced the Government to take up this important question. He was appointed forest-master, and was sent by Norway to examine in various countries of the north of Europe the methods observed for the preservation of timber. From these duties, in 1876, he withdrew with a pension; he died in Christiania on the 6th January 1885. From 1841 to 1852 Moe travelled almost every summer through the southern parts of Norway, collecting traditions in the mountains. He had, however, long intended to take holy orders, and in 1853 he did so, becoming for ten years a chaplain in Sigdal, and then (1863) parish priest of Bragernes. He was moved in 1870 to the parish of Vestre Aker, near Christiania, and in 1875 he was appointed bishop of Christianssand. In January 1882 he resigned his diocese on account of failing health, and died on the following 27th March. Moe has a special claim on critical attention in regard to his lyrical poems, of which a small collection appeared in 1850. He wrote little original verse, but in his slender volume are to be found many pieces of exquisite delicacy and freshness. Asbjornsen and Moe had the advantage of an admirable style in narrative prose. It was usually said that the vigour of it came from Asbjörnsen and the charm from Moe, but the fact seems to be that from the long habit of writing in unison they had come to adopt almost precisely identical modes of literary expression. (E. G.)

Ascension, an island situated in the Atlantic Ocean, 800 miles north-west of St Helena. It is described in the Reports of the *Challenger* as "a series of extinct volcano cones." Ascension was compared by Darwin "to a huge ship kept in first-rate order." It is under the jurisdiction of the Admiralty, is garrisoned by marines, and is rated as a ship of war. The bare hills have been covered with plants and shrubs, a road has been constructed for six miles from the landing-place, and a good water supply secured. The average rainfall is slight, March and April being the rainy months. Population, about 160 sailors, marines, and Krumen from the Liberian coast. Fish, turtle, and edible birds' eggs are the chief products.

Asch, a manufacturing town of Bohemia, in the government district of Eger, near the Saxon and Bavarian frontiers, and a station on the Bavarian State Railway. Population in 1890, 15,556; in 1900, 19,146 (all German—70 per cent. Protestant, 30 per cent. Roman Catholic). It is the seat of a Protestant superintendent, whose jurisdiction extends over fourteen villages, of which six are in Bavaria. It contains monuments to Luther and to the Germanizing and liberal Austrian emperor, Joseph II. Important textile industry employs 11,000 hands, and there are manufactures of knitted goods (2300 hands), leather, machinery, bleaching, dyeing, brewing, &c.

Aschaffenburg, a town of Bavaria, Germany, district Lower Franconia, on the right bank of the Main, 26 miles S.E. from Frankfort by rail. The parish church of Our Lady and the church of St. Agatha have been lately restored. There is an archæological museum. Ready-made clothing, paper, cellulose, tobacco, lime, and liqueurs are manufactured. Population (1900), 18,091. In March and July 1901 two suburbs were incorporated, raising the total population to 22,181.

Aschersleben, a town of Prussia, province of Saxony, 36 miles by rail N.W. from Halle. There are iron, zinc, and chemical manufactures, and the cultivation of agricultural seeds. Here are brine springs and baths. Population (1885), 21,519; (1900), 27,245.

Ascoli Piceno, a town and bishop's see of Italy (the Marches), capital of the province of Ascoli, situated on the E. side of the Apennines, 57 miles by rail S. from Ancona. The cathedral was restored in 1888, and is adorned with modern frescoes. There are an antiquarian museum, an agricultural school, and a training school for female teachers. The industries of Ascoli include silkworm breeding, flour-mills, brickworks, limekilns, potteries, and factories for furniture and vehicles. Population, commune (1881), 23,225, (1901), 28,882; province (1881), 209,185, (1901), 245,883.

Ashanti. See Gold Coast.

Ashby-de-la-Zouch, a market-town and railway station, in the Bosworth parliamentary division of Leicestershire, England, 16 miles N.W. by W. of Leicester. The old church of St. Helen has been restored and enlarged, a Queen Eleanor cross erected to the Countess of Loudoun, a grammar school built, the charity Bluecoat and Greencoat schools have been enlarged, and a cottage hospital has been opened. Area of urban district (co-extensive with parish), 6061 acres; population (1901), 4722.

Asheville, a city of North Carolina, U.S.A., and capital of Buncombe county. It is situated in the western, mountainous part of the state, in 35° 35′ N. lat. and 82° 33′ W. long., on a terrace above the French Broad, on the north bank, at the mouth of the Swananoa, and at an altitude of 2000 feet. The site is uneven and the plan is irregular. It is noted as a winter health resort, particularly for Northern people. It is entered by the Southern railway, by which it has connexions eastward and westward. It is the seat of Asheville Female College. Near it is Mr G. W. Vanderbilt's estate, Biltmore, of 100,000 acres, mainly forest land, on which tree culture has been conducted on a large scale. Population (1900), 14,694.

Ashford, a market-town and railway station in the Ashford parliamentary division of Kent, England, on the Esshe, a branch of the Stour, 14 miles S.W. of Canterbury. Ashford has agricultural implement works, breweries, and locomotive and carriage works. Area of urban district, 2850 acres; population (1891), 10,728; (1901), 12,808.

Ashland, a city of Boyd county, Kentucky, U.S.A., situated in the north-eastern part of the state, on the south bank of the Ohio and on the Chesapeake and Ohio railway, at an altitude of 537 feet. It has important iron manufactures and considerable commerce, especially by river. Population (1900), 6800.

Ashland, a borough of Schuylkill county, in eastern Pennsylvania, U.S.A., situated in the anthracite coal region, at an altitude of 856 feet; a coal-mining place on the Lehigh Valley and the Philadelphia and Reading railways. Population (1900), 6438.

Ashland, a city of Wisconsin, U.S.A., and capital of Ashland county, situated in the northern part of the state, at the head of Chaquamegon Bay, an arm of Lake Superior. It is in 46° 35′ N. lat. and 90° 58′ W. long., at an altitude of 678 feet. It was founded in 1885 by the discovery of the Gogebic Range iron mines, 40 miles south-east. Its plan is regular. The Northern Pacific, the Wisconsin Central, the Chicago, St Paul, Minneapolis, and Omaha, and the Chicago and North-Western railways serve it; and it has also an extensive lake commerce, principally in lumber and iron ore. Population (1890), 9956; (1895), 12,310; (1900), 13,074.

Ashtabula, a city of Ashtabula county, Ohio, U.S.A., in the north-eastern part of the state, near the shore of Lake Erie; altitude, 647 feet. It is an important railway centre, being traversed by two great trunk lines and the terminus of a third. Having a fine harbour, it is a considerable lake port, shipping vast quantities of iron ore, in transport from the iron ranges of Lake Superior to Pittsburg for smelting. Population (1900), 12,949.

Ashton-in-Makerfield, a township in the Newton parliamentary division of Lancashire, England, 7 miles N. by W. of Warrington. The district is rich in minerals and has large collieries, and a colliery company's institute; iron goods are manufactured. Area of urban district, 6250 acres. Population (1901), 18,687.

Ashton-under-Lyne, a municipal and parliamentary borough (one member) of Lancashire, England, on the Tame, 6½ miles E. of Manchester by rail. Modern structures are a church, a Congregational chapel (£50,000), a theatre, a technical school, a school of art and free library, a children's hospital, and a new post-office. The market-place and town hall have been enlarged. There is a public park of 64 acres. Population of municipal borough in 1881, 37,040; in 1891, 40,463; in 1901, 43,890. In November 1898, a portion of the urban district of Dukinfield in Cheshire was added to the borough of Ashton-under-Lyne, and part of the borough was transferred to Dukinfield. As rearranged, the municipal borough has an area of 1396 acres.

ASIA.

Recent changes in continental physiography.

NEXT to Africa, we shall probably find in Asia, oldest of the Old World continents, a greater store of new facts presented to us, or, it may be, of old facts with new features revealed by the light of modern scientific research, than in any other quarter of the globe. It is in the realm of physical geography, and its collateral branches of science, that we have chiefly to mark important accessions of knowledge; and the knowledge thus acquired is, throughout the continent, given to us rather in the form of more exact information than as absolutely new discovery which might lead to any large correction of preconceived ideas.

General Expansion of Exact Surveys.

The progress of geodetic surveys in Russia had long ago extended across the European half of the great empire, Petersburg being connected with Tiflis on the southern slopes of the Caucasus by a direct system of triangulation carried out with the highest scientific precision. Petersburg, again, is connected with Greenwich by European systems of triangulation; and the Greenwich meridian has been adopted by Russia as the zero for all her longitude values. But beyond the eastern shores of the Caspian no system of direct geodetic measurement by first-class triangulation has as yet been possible, and the surveys of Asiatic Russia are separated from those of Europe by the width of that inland sea. The arid nature of the trans-Caspian deserts has so far proved an insuperable obstacle to those rigorous methods of geodetic survey which distinguish Russian methods in Europe, so that Russian geography in Central Asia is dependent on other means than that of direct measurement for the co-ordinate values in latitude and longitude for any given point. The astronomical observatory at Tashkent is adopted for the initial starting-point of the trans-Caspian triangulation of Russia; the triangulation ranks as second class only, and now extends to the Pamir frontier beyond Osh. The longitude of the Tashkent observatory has been determined by telegraph differentially with Pulkova as follows:—

	H.	M.	S.
In 1875 *viâ* Ekaterinburg and Omsk .	2	35	52·151
,, 1891 ,, Saratow ,, Orenburg	2	35	52·228
,, 1895 ,, Kiew ,, Baku	2	35	51·997

With these three independent values, all falling within a range of $0^{s}{\cdot}25$, it is improbable that the mean value has an error as large as $0^{s}{\cdot}10$.

Extent of exact surveys in Asia.

Exact surveys in Russia, based upon triangulation, extend as far east as Chinese Turkestan in longitude about 75° E. of Greenwich. In India geodetic triangulation furnishes the basis for exact surveys as far east as the eastern boundaries of Burma in longitude about 100° E.

The years since 1875 have witnessed the forging of the final links in the great geodetic triangulation of India, so far as the peninsula is concerned. Further geodetic connexion with the European systems still remains to be accomplished. Since 1890 further and more rigorous application of the telegraphic method of determining longitudes differentially with Greenwich has resulted in a slight correction (amounting to about 2″ of arc) to the previous determination by the same method through Suez. This last determination was effected through four arcs as follows:—

I. Greenwich—Potsdam.
II. Potsdam—Teheran.
III. Teheran—Bushire.
IV. Bushire—Karachi.

Each arc was measured with every precaution and a multitude of observations. The only element of uncertainty was caused by the retardation of the current, which between Potsdam and Teheran (3000 miles) took $0^{s}{\cdot}20$ to travel; but it is probable that the final value can be accepted as correct to within $0^{s}{\cdot}05$.

The final result of this latest determination is to place the Madras observatory 2′ 27″ to the west of the position adopted for it on the strength of absolute astronomical determinations.

Connexion between Russian and Indian surveys.

But whilst we have yet to wait for that expansion of first-class geodetic triangulation which will bring Asia into connexion with Europe by the direct process of earth measurement, we have already effected a topographical connexion between Russian and Indian surveys which sufficiently proves that the deductive methods employed by both countries for the determination of the co-ordinate values of fixed points so far agree that, for all practical purposes of future Asiatic cartography, no difficulty in adjustment between Indian and Russian mapping need be apprehended. This connexion was effected near Lake Victoria during the Pamir Boundary Commission of 1895. The final values determined in longitude for the initial pillar of the boundary by the Russian and English surveyors respectively differed by about 1·0″ only, a difference which will never lead to serious difficulties in mutual map adjustment. In connexion with the Indian triangulation minor extensions carried out on systems involving more or less irregularity have been pushed outwards on all sides. They reach through Afghanistan and Baluchistan to the eastern districts of Persia, and along the coast of Makrán to that of Arabia. They have long ago included the farther mountain peaks of Nepal, and they now branch outwards towards Western China and into Siam. These far extensions furnish the basis for a vast amount of exploratory survey of a strictly geographical character, and they have contributed largely towards raising the standard of accuracy in Asiatic geographical surveys to a level which was deemed unattainable fifty years ago. There is yet a vast field open in Asia for this class of surveys. Whilst at the close of the 19th century Western Asia (exclusive of Arabia) may be said to be freed from all geographical perplexity, China, Mongolia, and Eastern Siberia still include enormous areas of which our geographical knowledge is in a primitive stage of nebulous uncertainty.

Extension of geographical surveys.

Explorations.

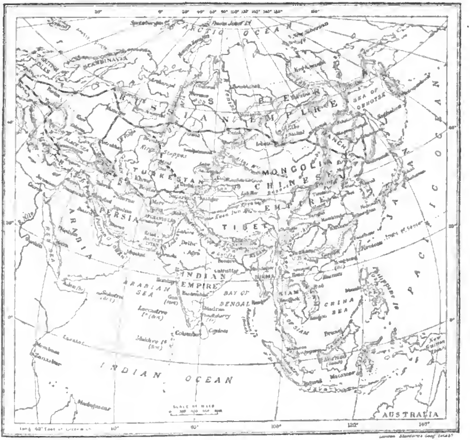
Of scientific geographical exploration in Asia (beyond the limits of actual surveys) the period since 1870 has been so prolific that it is only possible to refer in barest outline to some of the principal expeditions, most of which have been directed either to the great elevated tableland of Tibet, or to the central depression which exists to the north of it. In Southern Tibet the trans-Himalayan explorations of the native surveyors attached to the Indian survey, notably pundits Nain Sing and Kishen Sing, have added largely to our knowledge of the great plateau. Nain Sing explored the sources of the Indus and of the Upper Brahmaputra in the years 1865-67; and in 1874-75 he followed a line from the eastern frontiers of Kashmir to the Tengri Nor lake and thence to Lhasa, in which city he remained for some months. Kishen Sing's remarkable journey in 1879-82 extended from Lhasa northwards through Tsaidam to Sachu, or Saitu, in Mongolia. He subsequently passed through Eastern Tibet to

Indian explorers.

the town of Darchendo, or Ta Chien Lu, on the high road between Lhasa and Peking, and on the borders of China. Failing to reach India through Upper Assam he returned to the neighbourhood of Lhasa, and crossed the Himalayas by a more westerly route. Both these explorers visited Lhasa.

Russian explorers.

In 1871-73 the great Russian explorer, Prjevalski, crossed the Gobi desert from the north to Kansu in Western China. He first defined the geography of Tsaidam, and mapped the hydrography of that remarkable region, from which emanate the great rivers of China, Siam, and Burma. He penetrated southwards to within a month's march of Lhasa. In 1876 he visited the Lob Nor and discovered the Altyn Tagh range. In 1879 he followed up the Urangi river to the Altai mountains, and demonstrated to the world the extraordinary physical changes which have passed over the heart of the Asiatic continent since Chenghiz Khan massed his vast armies in those provinces. He crossed, and named, the Dzungarian extension of the Gobi desert, and then traversed the Gobi itself from Hami to Sachu, which became a point of junction between his journeys and those of Kishen Sing. He visited the sources of the Hoang-ho (Yellow river) and the Salween, and then returned to Russia. His fourth journey in 1883-85 was to Sining (the great trade centre of the Chinese borderland), and thence through Northern Tibet (crossing the Altyn Tagh to Lob Nor), and by the Cherchen-Kiria trade route to Khotan. From Khotan he followed the Tarim to Aksu.



SKETCH MAP OF ASIA.

Following Prjevalski the Russian explorers, Pevtsoff and Roborovski, in 1889-90 (and again in 1894) have added greatly to our knowledge of the topography of Western Chinese Turkestan and the northern borders of Tibet; all these Russian expeditions being conducted on scientific principles and yielding results of the highest value.

Other explorations in Central Asia.

Although the establishment of a lucrative trade between India and Central Asia had been the dream of many successive Indian viceroys, and much had been done towards improving the approaches to Simla from the north, very little was really known of the highlands of the Pamirs, or of the regions of the great central depression, before the mission of Sir Douglas Forsyth to Yarkand in 1870. Shaw and Hay-ward were the European pioneers of geography into the central dominion of Kashgar, arriving at Yarkand within a few weeks of each other in 1868. Shaw subsequently accompanied Forsyth's mission in 1870, when Trotter made the first maps of Chinese Turkestan. The next great accession to our knowledge of Central Asiatic geography was gained with the Russo-Afghan Boundary Commission of 1884-86, when Afghan Turkestan and the Oxus regions were mapped by surveyors under Holdich; and when Ney Elias crossed from China through the Pamirs and Badakshan to the camp of the commission, identifying the great "Dragon Lake," Rangkul, on his way. About the same time a mission, under Lockhart, crossed the Hindu Kush into Wakhan, and returned to India by the Bashgol valley of Kafiristan. This was Woodthorpe's opportunity, and he was then enabled to verify the results of M'Nair's previous explorations, and to determine the conformation of the Hindu Kush. In 1885 Carey and Dalgleish, following more or less the tracks of Prjevalski, contributed much that was new to the map of Asia; and in 1886 Younghusband completed a most adventurous journey across the heart of the continent by crossing the Muztagh, the great mountain barrier between China and Kashmir.

Tibetan explorations.

It was in 1886-87 that Bonvalot, accompanied by Prince Henri d'Orleans, crossed the Tibetan plateau from north to south, but failed to enter Lhasa. In 1889-91 the American traveller, Rockhill, commenced his Tibetan journeys, and also attempted to reach Lhasa, without success. By his writings, as much as by his explorations, Rockhill has made his name great in the annals of Asiatic research. In 1891 Bower made his famous journey from Leh to Peking. He, too, failed to penetrate the jealously guarded portals of Lhasa; but he secured (with the assistance of a native surveyor) a splendid addition to our previous Tibetan mapping. In 1891-92-93 the gallant French explorer, De Rhins, was in the field of Tibet, where he finally sacrificed his life to his work; and the same years saw Curzon in the Pamirs, and Littledale on his first great Tibetan journey, accompanied by his wife. Littledale's first journey ended at Peking; his second, in 1894-95, took him almost within sight of the sacred walls of Lhasa, but he failed to pass inside. Greatest amongst recent Asiatic explorers (if we except Prjevalski) is the brave Swede, Sven Hedin, whose travels through the deserts of Takhla Makan and Tibet, and whose investigations in the glacial regions of the Sarikol mountains, occupied him from 1894 to 1896. His is a truly monumental record. From 1896 to 1898 we find two British cavalry officers taking the front position in the list of Tibetan travellers—Wellby of the 18th Hussars, and Deasy of the 16th Lancers, each striking out a new line, and each rendering most valuable service to geography. The latter continued the Pamir triangulation, which had been carried across the Hindu Kush by Holdich and Wahab during the Pamir Boundary Commission of 1895, into the plains of Kashgar and to the sources of the Zarafshan.

Chinese explorations.

Meanwhile, in the farther east so rapid has been the progress of geographical research since the first beginnings of investigation into the route connexion between Burma and China in 1874 (when the brave Margary lost his life), that a gradually increasing tide of exploration, setting from east to west, and back again, has culminated in a flood of inquiring experts intent on economic and commercial development in China, essaying to unlock those doors to trade which are hereafter to be propped open for the benefit of humanity. Gill, of the Indian survey, first made his way across China to Eastern Tibet and Burma, and subsequently delighted the world with his story of the *River of Golden Sand*. Then followed another charming writer, Baber, who, in 1877-78, unravelled the geographic mysteries of the western provinces of the Celestial empire. Mark Bell crossed the continent in 1887, and illustrated its ancient trade routes, following the steps of Colquhoun, who wandered from Peking to Talifu in 1881. Meanwhile, the acquisition of Burma and the demarcation of boundaries had opened the way to the extension of geographical surveys in directions hitherto untraversed. Woodthorpe was followed into Burmese fields by many others; and amongst the earliest travellers to those mysterious mountains which hide the sources of the Irrawaddy, the Salween, and the Mekong, was Prince Henri d'Orléans. Burma was rapidly brought under survey; Siam was already in the map-making hands of M'Carthy, whilst Curzon and Warrington Smyth added much to our knowledge of its picturesque coast districts.

Indian frontiers—Afghanistan, Baluchistan. Persia.

Turning our attention westwards, no advance in the progress of scientific geography is more remarkable than that recorded on the northern and north-western frontiers of India. Here there is little matter of exploration. It has rather been a wide extension of scientific geographical mapping. The Afghan war of 1878-80; the Russo-Afghan Boundary Commission of 1884-85; the occupation of Gilgit and Chitral; the extension of boundaries east and north of Afghanistan, and again, between Baluchistan and Persia—these, added to the opportunities afforded by the systematic survey of Baluchistan which has been steadily progressing since 1880—have combined to produce a series of geographical maps which extend from the Oxus to the Indus, and from the Indus to the Euphrates.

In these professional labours the Indian surveyors have been assisted by such scientific geographers as Houtoum Schindler, Vaughan, and Sykes in Persia, and by Robertson and Cockerill in Kafiristan and the Hindu Kush.

Arabia.

In still more western fields of research much additional light has been thrown since 1875 on the physiography of the great deserts and oases of Arabia. The labours of Doughty and Blunt in Northern Arabia in 1877-78 were followed by those of Schweinfurth and Glaser in the south-west about ten years later. In 1884-85 Mills made his adventurous journey through Oman, whilst Bent threw searchlights backwards into ancient Semitic history by his investigations in the Bahrein Islands in 1888, and in Hadramut in 1894-95.

Northern Asia. Siberia, &c.

In Northern Asia it is impossible to follow in detail the results of the organized Russian surveys. The vast steppes and forest-clad mountain regions of Siberia have assumed a new geographical aspect in the light of these revelations, and already promise a new world of economic resources to Russian enterprise in the near future. A remarkable expedition by Baron Toll in 1892 through the regions watered by the Lena, resulted in the collection of material which will greatly help to elucidate some of the problems which beset the geological history of the world, proving *inter alia* the primeval existence of a boreal zone of the Jurassic Sea round the North Pole. The distinguished scientist, Richthofen, has enriched the world by the results of his investigations into the physiography of the North-East in China, Korea, and Japan.

It is not possible further to follow the footsteps of that great company of geographers of all nations who have searched for new material for the illustration of Asiatic geography, geology, and history. In no period of the world's history, of equal length of time, has so much scientific enterprise been directed towards the field of Asiatic inquiry as during the last quarter of the 19th century.

General Physiography of the Asiatic Continent.

Asia is divided laterally along the parallel of 40° N. lat. by a depression which, commencing on the east of the desert of Gobi, extends westwards through Mongolia to Chinese Turkestan. To the west of Kashgar the central depression is limited by the meridional range of Sarikol and the great elevation of the Pamirs, of which the Sarikol is the eastern face. The level of this depression (once a vast inland sea) between the mountains which enclose the sources of the Hoang-ho and the Sarikol range probably never exceeds 2000 feet above sea, and modern researches tend to prove that in the central portions of the Gobi (about Lob Nor) it may be actually below sea-level. A vast proportion of the continent north of this central line is but a few hundred feet in altitude. Shelving gradually upward from the low flats of Siberia the general continental level rises to a great central water-parting, or divide, which stretches from the Black Sea through the Elburz and the Hindu Kush to the Tian Shan mountains in the Pamir region, and hence to Bering Strait on the extreme north-east. This great divide is not always marked by well-defined ranges facing steeply either to the north or south. There are considerable spaces where the strike, or axis, of the main ranges is transverse to the water-parting, which is then represented by intermediate highlands forming lacustrine regions with an indefinite watershed. Only a part of this great continental divide (including such ranges as the Hindu Kush, Tian Shan, Altai, or Khangai) rises to any great height, a considerable portion of it being below 5000 feet in altitude. South of the divide the level at once drops to the central depression of Gobi, which forms a vast interior, almost waterless, space, where the local drainage is lost in deserts or swamps. South of this enclosed depression is a second great hydrographic barrier which parts it from the low plains of the Amur, of China, Siam, and India, sinking into the shallows of the Yellow Sea and the shoals which enclose the islands of Japan and Formosa, all of them once an integral part of the continent. This second barrier is one of the most mighty upheavals in the world, both by reason of its extent and its altitude. Starting from the Amur river and reaching along the eastern margin of the Gobi desert towards the sources of the Hoang-ho, it merges into the Altyn Tagh and the Kuen Lun, forming the northern face of the vast Tibetan highlands which are bounded on the south by the Himalaya. This great lacustrine plateau averages 15,000 feet above sea-level. The Pamir highlands between the base of the Tian Shan mountains and the eastern buttresses of the Hindu Kush unite these two great divides, enclosing the Gobi depression on the west; and they would again be united on the east but for the transverse valley of the Amur, which parts the Kinghan mountains from the Yablonoi system to the east of Lake Baikal.

If we consider the whole continent to be divided into three sections, viz., a northern section with an average altitude of less than 5000 feet above sea, where all the main rivers flow northward to the Mediterranean, the Arctic Sea, or the Caspian; a central section of depression, where the drainage is lost in swamps or "hamúns," and of which the average level probably does not approach 2000 feet above sea; and a southern section divided between highly elevated tablelands from 15,000 to 16,000 feet in altitude, and lowlands of the Arabian, Indian, Siamese, and Chinese peninsulas, with an ocean outlet for its drainage, we find that there is only one direct connexion between northern and southern sections which involves no mountain passes, and no formidable barrier of altitudes. That one is afforded by the narrow valley of the Hari Rud to the west of Herat. From the Caspian to Karachi it is possible to pass without encountering any orographic obstacle greater than the divide which separates the valley of the Hari Rud from the Helmund "hamún" basin, which may be represented by an altitude of about 4000 feet above sea-level. This fact possesses great significance in connexion with the development of Asiatic railways.

Hydrography.—If we examine the hydrographic basins of the three divisions of Asia thus indicated we find that the northern division, which includes the drainage falling into the Arctic Sea, the Aralo-Caspian depression, or the Mediterranean, embraces an area of about 6,394,500 square miles, as follows:—

	Sq. miles.
Area of Arctic river basins	4,367,000
,, Aralo-Caspian basin	1,759,000
,, Mediterranean	268,500
Total . . .	6,394,500

The southern division is nearly equal in extent—

	Sq. miles.
Pacific drainage	3,641,000
Indian Ocean	2,873,000
Total . . .	6,514,000

The interior or inland basins, including the lacustrine regions south of the Arctic watershed, the Gobi depression, Tibetan plateau, the Iranian (or Perso-Afghan) uplands, the Syro-Arabian inland basin, and that of Asia Minor, amount to 3,141,500 sq. miles, or about half the extent of the other two.

By far the largest Asiatic river basin is that of the Ob, which exceeds 1,000,000 sq. miles in extent. On the east and south the Amur embraces no less than 776,000 sq. miles, the Yang-tse-kiang including 685,000, the Ganges 409,500, and the Indus 370,000 sq. miles.

The *lakes* of Asia are innumerable, and vary in size from an inland sea (such as Lakes Baikal and Balkash) to a highland loch, or the indefinitely extended swamps of Persia. Many of them are at high elevations (Lake Victoria, 13,400 feet, being probably the most elevated), and are undoubted vestiges of an ancient period of glaciation. Such lakes, as a rule, show indications of a gradual decrease in size. Others are relics of an earlier geological period, when land areas recently emerged from the sea were spread at low levels with alternate inundations of salt and fresh water. Of these Lob Nor and the Helmund "hamúns" are typical. Such lakes (in common with all the plateau "hamúns" of S.W. Baluchistan and Persia) change their form and extent from season to season, and many of them are impregnated with saline deposits from the underlying strata. The "kavirs," or salt depressions, of the Persian desert are more frequently widespread deposits of mud and salt than water-covered areas.

Geology.—Over a great part of Asia, including the Caspian depression, the Central Asian Khanates, Turkestan, Tibet, China, Siberia, and India, geological research has been closely, and, in many regions, scientifically pursued. The results of such investigations are at present too disconnected and fragmentary to afford material for the construction of a continuous geological history of the formation of the whole continent. They have mainly been directed to those regions whose economic development seems possible, and whose resources of mineral wealth may be expected to enrich the world.

The great Caspian depression and its extension to the Aral Sea has been examined by Russian scientists, and the old theory of the former Oxus contribution to the Caspian finally dismissed. Whilst the extent and nature of these beds of an ancient western ocean have been under investigation, the Central Sea to the east of the Pamirs, represented by the Gobi Sands, the Tarim desert, and by the shallow lakes and swamps of Lob Nor, has also received much attention; but it has not yet been exhaustively explored, and we await the results of Sven Hedin's expedition to decide the position and extent of its possible survival in the existing lake system. Geological researches in Siberia have proved the existence of almost boundless sources of mineral wealth in the north. Explorations in China have opened up new and vast fields for mining industry in the east; and the plains of India and Burma appear in a new light under the display of economic possibilities which the systematic labours of the Geological Survey of India have revealed. Never perhaps in the world's history has the importance of investigating old fields by the newest lights of science been so fully illustrated as in Asia during the last quarter of the 19th century. Changes in the configuration of the continent, due to slow processes of upheaval and subsidence, have been proved not only to have taken place in the past, and thereby modified climatic conditions, and to have sensibly affected the history of the human race in Asia, but their continued action can be traced in the present, and in one instance at least (in Turkestan) the actual measurement of the progress in upheaval has been found possible.

Physical changes in the earth's crust.

One of the most remarkable discoveries of the last decade of the 19th century is the continuation westwards through Baluchistan to the Persian border of that line of volcanic activity which, commencing in Kamchatka, and following the eastern coast-line of Asia to the Malay archipelago, there turns westward to the Sea of Bengal and is arrested in Arakan. No trace of it is to be found in the line of depression formed by the Indo-Gangetic alluvial plain across the width of the Indian peninsula, but it is again manifest in the active mud volcanoes of the Makrán coast, and continues trending slightly north of west to the Persian frontier, where in (approximate) lat. 28° 30′ N. and long. 61° E. it culminates in a giant inland volcano called the Koh-i-Taftan, or "burning" mountain. The highest peak of this mountain is 13,480 feet above sea-level, and from it there issues a perpetual pillar of smoke, which hangs heavily above the snow-clad summit. This volcano (which has been ascended by Captain Sykes) is, so far as is known at present, the only inland volcano in Asia. Its position has been well fixed from the Baluchistan survey bases.

Volcanoes.

In India geological science has shaped the historical outline for the evolution of geography from the early ages, when a land connexion existed between India and Africa, to the gradual and slow process of Himalayan upheaval, and the formation of the Himalayan valleys, by erosion, in the form in which we now see them. The entire peninsular area, including the north-west borderlands and Burma, are shown to have been submerged when the greater part of the peninsula (including the Gangetic basin) existed in the form of dry land, and the fascinating theory of a continuous sea which united the basins of the Indus and Ganges has to be given up. Many of the shifting changes which have occurred in the channels of great rivers are matters of history, as are some of the alterations in the coast-line, which can be readily traced on the Makrán seaboard and between Bombay and Karachi.

Geological history of India.

Climate.—Although the general nature of those influences which govern the phenomena of climate over the broad area of the Asiatic continent have been fairly well established, yet the improvements in the methods of meteorological science and the establishment of centres for the record of observed phenomena over a very wide extent of Southern and Western Asia have much improved our knowledge of local cause and effect, and have especially assisted in supplying those data which enable meteorologists to determine the probable course and duration of disturbances, or, in other words, to make "weather forecasts." Improved means of telegraphic communication have added greatly to the facilities with which such prevision is rendered possible. For instance, the atmospheric conditions prevailing in early summer in the neighbourhood of the Seychelles Islands indicate the probable force and fulness of the monsoon on which the prospects of Indian agriculturists so largely depend; and much loss of life and property is undoubtedly averted by the comparative facility with which the probable course of hurricanes and cyclones can be foreseen and the necessary precautions signalled. In the field of investigation into climatic influence on the conditions of life, and ultimately of human existence, considerable advance has been made of late years, with results that will be more beneficial than they are at present when the theories which support them become more fully confirmed and recognized. The proposition that malarial fever is directly propagated by a special breed of mosquito is one of the theories which is new to science at present, and can now be said to be fully accepted. It is one of several which emanate from closer research into the intimate relations between atmospheric and biological conditions.

Tides.—Collaterally with investigation into the movements of great air-currents special study has been directed to tidal phenomena along the coasts of Western Asia. Tidal stations have been established on the coasts of India, at Aden and Suez, where a graphic form of registration supplies those data from which tidal elements can be calculated and curves representing momentary variation in the height of sea-level during any period can be constructed. In connexion with these tidal observations extensive levelling operations in India have been carried out to ascertain whether there is any appreciable difference in mean sea-level at various points. The immediate practical benefit of these tidal determinations to the science of navigation is obvious. One of the ultimate results of them will be to supply a more assured basis than exists at present for the determination of altitudes over the land surface of Southern Asia.

Recent Investigations.—The first great result of recent geographical research has been to modify pre-existing ideas of the orography of the vast central region represented by Tibet and Mongolia. The great highland plateau which stretches from the Himalaya northwards to Chinese Turkestan, and from the frontier of Kashmir eastwards to China, has now been defined with comparative geographical exactness. The position of Sachu (or Saitu) in Mongolia may be taken as an obligatory point in modern map construction. The longitude value now adopted is 94° 54′ E. of Greenwich, which is the revised value given by Prjevalski in the map accompanying the account of his fourth exploration into Central Asia. Other values are as follows:—

Prjevalski, by his second and third explorations	94° 26′
Krishna	95° 23′
Carey and Dalgleish	94° 48′
Littledale	94° 49′
Kreitner (with Szechenyi's expedition) .	94° 55′

The longitude of Darchendo, or Ta Chien Lu, on the extreme east, may be accepted as another obligatory point. The adopted value by the Royal Geographical Society is 102° 12′.

Krishna gives	102° 15′
Kreitner	102° 5′
Baber	102° 18′

South and west the bounding territories are well fixed in geographical position by the Indian survey determinations of the value of Himalayan peaks. On the north the Chinese Turkestan explorations are now being brought into survey connexion with Kashmir and India.

No longer do we regard the Kuen Lun mountains, which extend from the frontiers of Kashmir, north of Leh, almost due east to the Chinese province of Kansu, as the southern limit of the Gobi or Turkestan depression. This very remarkable longitudinal chain is undoubtedly the northern limit of the Chang Tang, the elevated highland steppes of Tibet; but from it there branches a minor system to the north-east from a point in about 83° E. longitude, which culminates in the Altyn Tagh, and extends eastwards in a continuous water-divide to the Nan Shan mountains, north of the Koko Nor basin. Thus between Tibet and the low-lying sands of Gobi we have, thrust in, a system of elevated valleys (Tsaidam) 8000 to 9000 feet above sea-level, forming an intermediate steppe between the highest regions and the lowest, east of Lob Nor. All this is comparatively new geography, and it goes far to explain why the great trade routes from Peking to the west were pushed so far to the north.

Russo-Chinese boundary.

On the western edge of the Kashgar plains, the political boundary between Russia and China is now defined by the meridional range of Sarikol. This range (known to the ancients as Taurus, and in medieval times as Bolor) like many others of the most important great natural mountain divisions of the world, consists of two parallel chains, of which the western is the water-divide of the Pamirs, and the eastern (which has been known as the Kashgar or Kandar range) is split at intervals by lateral gorges to allow of the passage of the main drainage from the eastern Pamir slopes. It is on this eastern ridge that the highest peaks at present known north of the Himalaya have been fixed. Here is the Muztagh Ata of Sven Hedin (not to be confounded with the Muztagh range on the Kashmir frontier), whose height has been determined to be 24,000 feet above sea-level; and there are other peaks on this eastern ridge which may possibly be found to approach this value closely, when their altitude has been scientifically determined.

The central continental water-divide.

The Sarikol range marks the position of the great water-divide between the Aralo-Caspian basin and the central system of hydrography terminating in the Lob Nor depression. Immediately between the Sarikol and the Kashgar (or Kandar) are the lowlands of the Sarikol valley, of which the Taghdumbash Pamir forms a southern extension. The tri-junction of the boundaries of three great empires—Russia, China, and British India—is not inappropriately situated near the tri-junction of three great Asiatic mountain systems where the Sarikol range, reaching southwards to a junction with the Hindu Kush and the Muztagh ranges, defines the head of the Taghdumbash Pamir.

From this point the Hindu Kush trends westwards and south-westwards, overlooking the narrow valley of the Panja (one of the main Oxus affluents on the north) till it merges beyond Kabul into the mountains which separate Afghanistan from Afghan Turkestan.

Hindu Kush and Muztagh ranges.

From the same point the Muztagh mountains stretch eastwards and southwards, separating the sources of the Zarafshan, or river of Yarkand, from the gigantic glacier region of Northern Kashmir. Much has been done towards elucidating the exact configuration of both of these important ranges. The Hindu Kush has been crossed at several points, and it is only where it passes through the unexplored wilderness of Kafiristan that the position of the main water-divide is at all doubtful. The Muztagh has been crossed once (by Younghusband) at a point where its passage may be considered to be ordinarily impracticable, not far from the gigantic peak Godwin Austen, which ranks as second only to Everest in the scale of Himalayan altitudes. Much practical gain (political and military) has been derived from a better appreciation of the physical characteristics of the mass of mountainous country which intervenes between the north of India and the southern borders of Asiatic Russia; and much has been attained in the more western regions, which include Northern Afghanistan and Persia.

Indian frontiers—Afghanistan, &c.

In Western Asia we have learned the exact value of the mountain barrier which lies between Merv and Herat, and have mapped its connexion with the Elburz of Persia. We can now fully appreciate the factor in practical politics which that definite but somewhat irregular mountain system represents which connects the water-divide north of Herat with the southern abutment of the Hindu Kush, near Bamian. Every pass of importance is known and recorded; every route of significance has been explored and mapped; Afghanistan has assumed a new political entity by the demarcation of a boundary; the value of Herat and of the Pamirs as bases of aggression has been assessed, and the whole intervening space of mountain and plain thoroughly examined.

Persia.

Although within the limits of Western Asiatic states, still under Asiatic government and beyond the active influence of European interests, the material progress of the Eastern world has appeared to remain stationary, yet large accessions to geographical knowledge have at least been made, and in some instances a deeper knowledge of the surface of the country and modern conditions of life has led to the straightening of many crooked paths in history, and a better appreciation of the slow processes of advancing civilization. The steady advance of scientific inquiry into every corner of Persia, backed by the unceasing efforts of a new school of geographical explorers, has left nothing unexamined that can be subjected to superficial observation. The geographical map of the country is fairly complete, and with it much detailed information is now accessible regarding the coast and harbours of the Persian Gulf, the routes and passes of the interior, and the possibilities of commercial development by the construction of trade roads uniting the Caspian, the Karun, the Persian Gulf, and India, *vid* Sistan. Persia has assumed a comprehensible position as a factor in future Eastern politics. (See PERSIA.)

Arabia.

In Arabia progress has been slower. Little more is known of the wide spaces of interior desert than has already been given to the world in the works of Burton, Palgrave, and Pelly amongst Englishmen, and Niebuhr, Burckhardt, Visconte, Halévy and others, amongst foreign travellers. Doughty and Blunt have visited and illustrated the district of Nejd, and described the waning glories of the Wahabi empire. But extended geographical knowledge does not point to any great practical issue. Commercial relations with Arabia remain much as they were in 1875. (See ARABIA.)

Asia Minor, &c.

In Asia Minor, Syria, and Mesopotamia there is little to record of progress in material development beyond the promises held out by the Euphrates Valley Railway concession to a German company. The exact information obtained by the researches of English surveyors in Palestine and beyond Jordan, or by the efforts of explorers in the regions that lie between the Mediterranean and the Caspian, have so far led rather to the elucidation of history than to fresh commercial enterprise or the possible increase of material wealth.

Russia in Asia.

Asiatic Russia, especially Eastern Siberia and Mongolia, have been brought within the sphere of Russian exploration, with results so surprising as to form an epoch in the history of Asia. Here there has been a development of the resources of the Old World which parallels the best records of the New. Further references to the results of recent Russian enterprise will be made when considering the general question of Asiatic progress.

Chinese Turkestan and Oxus basin.

The great central depression of the continent which reaches from the foot of the Pamir plateau on the west through the Tarim desert to Lob Nor and the Gobi is still under examination. This vast area of low elevation centres about Lob Nor, where we find, in a lake system (the full details of which are not yet fully known, although much has been recorded of them by Prjevalski and Sven Hedin), the last surviving evidences of a great inland sea. The depression westward of the Caspian and Aral basins, and the original connexion of these seas, has also come under the close investigation of Russian scientists, with the result that the theory of an ancient connexion between the Oxus and the Caspian has been displaced by the more recent hypothesis of an extension of the Caspian Sea eastwards into trans-Caspian territory within the post-Pleiocene age. The discovery of shells (now living in the Caspian) at a distance of about 100 miles inland, at an altitude of 140 to 280 feet above the present level of the Caspian, gives support to this hypothesis, which is further advanced by the ascertained nature of the Kara-kum sands, which appear to be a purely marine formation exhibiting no traces of fluviatile deposits which might be considered as delta deposits of the Oxus.

In the discussion of this problem we find the names of Kaulbars, Anneukoff, Lessar, and Konshin prominent. Further matter of interest in connexion with the Oxus basin was elucidated by the researches of Griesbach in connexion with the Russo-Afghan Boundary Commission. He reported the gradual formation of an anticlinal, or ridge, extending longitudinally through the great Balkh plain of Afghan Turkestan, which effectually shuts off the northern affluents of that basin from actual junction with the river. This evidence of a gradual process of upheaval still in action may throw some light on the physical (especially the climatic) changes which must have passed over that part of Asia since Balkh was the "mother of cities," the great trade centre of Asia, and the plains of Balkh were green with cultivation. In the restoration of the outlines of ancient and mediæval geography in Asia Sven Hedin's discoveries of the actual remains of cities which have long been buried under the advancing waves of sand in the Takla Makan desert, cities which flourished in the comparatively recent period of Buddhist ascendancy in High Asia, is of the very highest interest, filling up a blank in the identification of sites mentioned by early geographers and illustrating more fully the course of old pilgrim routes.

Baluchistan and Makrán.

With the completion of the surveys of Baluchistan and Makrán much light has also been thrown on the ancient connexion between east and west; and the final settlement of the southern boundaries of Afghanistan has led to the reopening of one at least of the old trade routes between Sistan and India. (See BALUCHISTAN.)

Between Burma and China.

Farther east no part of Asia has been brought under more careful investigation than the hydrography of the strange mountain wilderness that divides Tibet and Burma from China. In this field the researches of travellers already mentioned, combined with the more exact reconnaissance of native surveyors and of those exploring parties which have recently been working in the interests of commercial projects, have left little to future inquiry. We know now for certain that the great Tsangpo of Tibet and the Brahmaputra are one and the same river; that north of the point where the great countermarch of that river from east to west is effected are to be found the sources of the Salween, the Mekong, the Yang-tse-kiang and the Hoang-ho, or Yellow river, in order, from west to east; and that south of it, thrust in between the extreme eastern edge of the Brahmaputra basin and the Salween, rise the dual sources of the Irrawaddy. From the water-divide which separates the most eastern affluent of the Brahmaputra, eastwards to the deep gorges which enclose the most westerly branch of the upper Yang-tse-kiang (here running from north to south), is a short space of 100 miles; and within that space two mighty rivers, the Salween and the Mekong, send down their torrents to Burma and Siam. These three rivers flow parallel to each other for some 300 miles, deep hidden in narrow and precipitous troughs, amidst some of the grandest scenery of Asia; spreading apart where the Yang-tse takes its course eastwards, not far north of the parallel of 25°.

The comparatively restricted area which still remains for close investigation includes the most easterly sources of the Brahmaputra, the most northerly sources of the Irrawaddy, and some 300 miles of the course of the Upper Salween.

Ancient Trade Routes and Modern Railways.

No branch of knowledge gained by the results of recent Asiatic research is more instructive than the comparison of ancient means of trade communication with modern, the directions along which the wealth of East and West has been interchanged at various epochs in the world's history, and the means and methods of its propulsion. "The struggle for these trade routes forms a key to the policy and the wars of many nations"; and even if the command of them was "the expression rather than the cause of the aggrandisement of a nation," examples in which "the possession of Asiatic trade[1] has marked high water in the history of empire and its loss marked the ebb of the tide" are so frequent and so conspicuous in the world's great chronicle that no general consideration of the physiography of the continent of Asia can be regarded as complete without a reference to them. The two earliest civilized communities that created a demand for trade were, undoubtedly, Egypt on the west and China on the east: and thus from the earliest historical times there has not only existed a right-of-way to traders across the entire continent of Asia, but we can faintly trace the dawn of a sea-borne traffic in the records of Egyptian fleets in the Red Sea and of Chinese junks east of Ceylon. The great development of Asiatic trade has, however, been in hands that are neither Egyptian nor Mongolian, but which belonged to Semitic races—Jews, Phœnicians, or Sabæan Arabs; and clear history only begins with those early days when Arabs were masters of the Eastern seas, with settlements on the coast of India, in Ceylon, in the Straits, and China, as well as on the shores of Eastern Africa—if indeed they were not planted in the interior of that continent. Egypt, Assyria, Babylon, Persia, Macedonia, had each secured the right of trade to Eastern Asia in turn, and each in turn had lost it when Rome appeared in the field, and for seven centuries (from 1st century B.C. to the 6th A.D.) held more or less complete command of the regions intervening between Eastern Asia and the Mediterranean. But Egyptians were busy with their ships whilst Rome held command on land. The Arabs gradually superseded the Egyptians on the high seas, and ere the days of Islam had already established themselves as the greatest nation of traders that the world had ever seen. The conquest of Sind (in the 8th century A.D.) led to the establishment of a land route through Makrán, north of the Arabian Sea, to the Indus valley. The port of Tiz, in the bay of Chabar, was the terminus of the voyage eastwards of the Arab merchantmen, and from Tiz through Kiz, or Kej, to Bela and the Indus valley the journey was performed on land. From the far east the clumsy Chinese junk met the buggalow of the Arab at Ceylon. Here cargoes were exchanged, and thus for centuries the trade between East and West was maintained by sea till the Cape route was discovered by a Portuguese explorer and the whole traffic of the East diverted into new channels. From prehistoric days the land routes of Asia have remained much the same through the eastern parts of the continent. The geographical position of Kashgar, almost on the same parallel of latitude as Peking, with nearly 2000 miles of low-lying desert and steppe intervening, and forming a long narrow area of depression between the Tibetan plateau and the Tian-Shan mountains, a depression which, so far as we know, between Kashgar and the Upper Amur never rises above 2000 feet above sea-level and may sink to less than 500, renders it an almost obligatory point in any line of trade connecting China and the Caspian. All recent travellers have confirmed its importance, and we find several routes from the east gathering themselves at Kashgar before diverging again westwards. Only one route of any importance passes to the north of Kashgar, *i.e.*, that which, following the modern track between Peking and Hami, strikes off from the latter place to Urumtsi and Kulja, instead of passing through Aksu, south of the Tian-Shan, to Kashgar. Another route which was much used by the silk traders from Central China passes through Sining-fu (east of Koko Nor), and skirts the northern foot of the Altyn Tagh and the southern edge of the Tarim desert. From Kashgar westwards over the elevated region of the Pamirs the most direct route follows the Kashgar river to its source, and, crossing the great continental water-divide by the passes which lead into the Altai valley, makes its way by the fertile banks of the Surkhab to the Oxus. But from the southern towns of Chinese Turkestan, which group themselves along the foot of the Kuen Lun and once spread into the plains of Lob Nor and the Takla Makan desert, the road to the Oxus lay through Tashkurghan (the "stone tower" of medieval geography) and by the passes of the Sarikol to the great Pamirs and Lake Victoria. There can be little doubt that this was a much-traversed Khafila route during the middle centuries of our era. From Lake Victoria it passes to Ishkashim and across Badakshan to Afghan Turkestan and Herat or Mashad.

---

[1] Hunter, *Hist. of India*, vol. i.

Land route from Persia to India.

Trade routes of Asia.

The route from India *viâ* Kandahar, Kirman, and Babylon was well enough known in Alexander's time, but it is only lately that the facilities of it have been fully demonstrated. In later years trade found its way from the Indus valley to the Oxus *viâ* Kabul and Balkh, and thence passed north of the Caspian into Russia, or else by Tabriz and Tiflis to the Black Sea and Constantinople. When the Arabs prevailed in Asia, and Baghdad became the capital of the Caliphs, the Euphrates valley and Syria again were filled with Eastern merchandise. Then the Saracen gave place to the Crusader, and the command of the greatest trade routes of Asia was in the hands of Christians. In 1258 Baghdad fell before the Mogul, and by the commencement of the 15th century Turks and Mongols had blocked the Syrian outlet. For 200 years previously Venetians and Genoese had developed the overland trade between India and Europe *viâ* the Black Sea, and rendered themselves supreme in the Mediterranean. Venetian influence may still be traced along the coast districts of Persia and Makrán to Western India. In Makran Venetian gold coins were till quite recently recognized as the only gold currency.

It was the barrier set by the Mogul that started the Portuguese quest for a new sea route, and thus was initiated that line of sea traffic round the Cape of Good Hope which revolutionized the whole system of Eastern trade. Now, once again has the Red Sea resumed its pre-eminence in the commercial geography of the world. The ships of Tarshish are replaced by the modern ocean liners. But no developments corresponding in space have distinguished the methods of land transport. For a vast part of Asia the slow-moving camel is still the mainstay of the merchant traveller; and there is as yet no land connexion between Europe and Eastern Asia that will compete with the facilitated sea route. But we are within a measurable distance of witnessing such an overland connexion, and we are meanwhile already in possession of such perfected systems of local communication in India as render her railway developments of the last quarter of the 19th century distinguished in the annals of the world's progress.

Sea routes.

The first great continental line of railway which will bring Western Europe into touch with Eastern Asia will be that of Siberia. The Russian system connects St Petersburg with the Asiatic frontier by a line which is rather more than 1700 miles in length, passing through Moscow. From the Asiatic frontier eastwards, the Western Siberia line now extends to beyond the 90th meridian of east longitude, linking up with the Central Siberian line, which will touch Lake Baikal at Irkutsk. So far the traffic returns have shown a steady increase as the various sections of the line have been opened, and so great an expanse of trade is anticipated that the line is now being adapted for the service of at least eight pairs of trains, instead of the three for which the original calculations were framed. From Irkutsk eastwards the trans-Baikal and Manchurian sections of this great continental line will extend to a junction with the Usuri railway of the Amur river basin, of which the terminal port is at Vladivostok, on the Pacific coast. A part of the Usuri line is already complete. It was initiated by the present emperor on the 19th May 1891. The Baltic and Pacific will thus be connected by a line which will be little short of 6000 miles in length, covering nearly a quarter of the circumference of the globe. A remarkable feature in this enterprise is that the railway traverses those vast steppes and wide uplands which have historically been regarded as the waste lands of Asia, passing far to the north of the teeming districts whose wealth has been the desire of the nations from time immemorial. Undoubtedly it will eventually be connected with Central China and Peking, but at present the tardily recognized resources of Siberia alone are held amply to justify the construction of this magnificent line. Farther south, the ports of the Caspian have been connected by rail with the Central Asian Khanates by a line which passes along the foot of the northern slopes of the Persian Elburz to Merv, Bokhara, and Samarkand. Here, again, the advent of the railway is marked by enormous commercial developments, and the province of Ferghana already reproduces the smiling landscapes of Central Asia ere the days of Mogul devastation.

Russian railways.

Whilst Russia has been so busy, India (strictly within the limits of her own borders) has effected even more in actual length of railway extension. An extent of line which would nearly circle the globe (about 23,000 miles) represented the railway traffic capabilities of India at the close of the 19th century, and of this amount three-fourths at least have been brought into existence since 1875. The record of the many schemes which have resulted in so great an accession of trade arteries belongs to the annals of India. They can hardly be called continental, for as yet no definite proposal has taken practical shape which will end in linking India with Europe. Between India and China there is indeed a prospect of the evolution of a practical scheme of connexion. The extension of Burmese railways northwards to Mogaung, in the Upper Irrawaddy basin, and north-eastwards from Mandalay to the Kunlon ferry on the Salween, points the way to further extensions which will unite Dibrugarh, in Upper Assam, with Mogaung, and the Kunlon ferry with Talifu, in the Chinese province of Yun-nan. But at present, with all the wealth of interior railway development which has distinguished the close of the century, both within the peninsula of India and in Burma, the two still remain unconnected and, in a measure, isolated from the rest of the world.

Indian railways.

Chinese railways.

China.—In China we find perhaps the most noteworthy record of Asiatic national evolution that the history of the 19th century can show. It is not a long record, but it is a most surprising one. The old order has changed; the conservatism of her political principles is disappearing; the bulwark of national antipathy to foreign innovations has been broken through, and the sacred seclusion that hedged about the Imperial Court has been invaded. The birth of a new century will herald the birth of a new era for China—an era of railways and company projectors, and mining developments; the scattering of empire; the burial of prehistoric isolation and dignity. The record of China's late achievements in material progress so far is not a long one, but its promise is great, for it is a practical indication that the hostility of China to the introduction of railways has at last disappeared. The first railway from Shanghai to

Wusung (on the coast) was laid in 1876, and was eagerly utilized. The following year it was torn up by the authorities. The next temporary line (which tapped the Kaiping collieries and extended to the Taku forts) is now replaced by a permanent connexion between these (now demolished) forts and Tientsin, and extends north-eastwards into Manchuria. In 1897 a line was laid from Peking to Tientsin—73 miles—and it is already doubled. Another railway is under construction by a Belgian company which will ultimately connect Peking with Hankow on the Yang-tse-kiang, and a new line now links Shanghai with Wusung. These, with a few short industrial lines for the conveyance of material in the Yang-tse basin, are all that exist. The great extent of waterways in China undoubtedly reduces the prospective profits of railway undertakings, as they have formed the great natural trade arteries of the country from time immemorial. But considering the length of the great river channels and the volume of the river discharge, the length of the actual waterway is comparatively small. Explorations have only lately been carried into the basins of the Upper Yang-tse tributaries by the agents of European syndicates to determine their possible value as lines of internal trade communication either by rail or river, and the result will probably be a development of steam navigation in the Min and Kialing affluents of the Yang-tse, and a possible railway connexion between Burma and Central China. An extension from the Russian-Siberian system into Manchuria, and a connexion between the Central Siberian railway and Central China, are the chief continental projects now before the world.

Persia.—The development of roads in Persia has been slow, but not unimportant. Railways do not exist. The opening of the Karun river to navigation in 1889 was the first step towards an awakening of commercial speculative interest in Persia, which has not been altogether unproductive of benefit to the country. Hitherto this country, which includes more than half a million square miles of territory without navigable rivers (except about 200 miles of the Karun), and nine millions of intelligent and industrious inhabitants, has had to "carry on its foreign trade and local traffic along mule tracks, the like of which are hardly to be met with in any other part of the world, however backward." In 1880 a cart road was constructed between Tehran (or *Teheran*, the latter being more popular but less correct) and Kasvin (96 miles); in 1883 Tehran was connected with Kum (97 miles); and in 1890 Mashad and Askabad, in Russian territory, were united by a more or less metalled road 150 miles in length. Concessions have been granted for the construction of roads between Tehran and Ahwaz, with a branch road to Ispahan from Burujird; between Tehran and Baghdad; Tabriz and Astara; Tabriz and Bayazid; Zinjan and Burujird; Kazvin and Hamadan; and Kazvin and Resht; but only the last, the concession for which was granted in 1893, has become a *fait accompli* so far. This road has been engineered by Russians, and has largely widened the circle of her Persian trade. It has also shortened the distance between Europe and Tehran, which place can now be reached from London, in case of urgency, within two weeks *viâ* Baku and Resht. The road from Tehran to Ahwaz (530 miles) has advanced as far as Kum, and the opening of a trade route between Shuster and Ispahan through the Baktiari country has been secured politically; but much remains to be done on both these lines. A new route from which great trade results are anticipated has been opened between Persia and India. This connects Mashad with Quetta on the Indian railway system by way of Sistan and Nushki, passing through the Helmund desert. On the north-west, Russian railways are rapidly approaching Persia; and the completion of the Tiflis, Alexandropol-Kars line, with a branch line from Alexandropol to Erivan, will greatly affect the current of Persian trade. The result of these railway developments on the north-west of Persia will be to increase the importance of Tehran as a trade centre, and to draw away traffic from the southern ports.

In *Asia Minor* and *Syria* progress in railway development has been slow, but the recent concession to an Anatolian company for the Euphrates valley line may reawaken commercial activity in this part of Asia. A line from the Bosporus to Angora, and another from Smyrna to Konieh, represent the chief railway systems of Asia Minor at present. In Syria the Beirut-Damascus and Jaffa-Jerusalem lines exhibit little prospect of extension.

Economic Developments and Commercial Enterprise in Asia.

It will be found, as might naturally be expected, that increase of material wealth and of commercial importance amongst Asiatic countries has been coincident with the development of trade routes and railways. Although Asia is the oldest amongst the historically recognized continents of the world, and although it was in Asia that the "cradle of civilization" was rocked, it has remained for the later centuries of our era, and especially for the latter part of the 19th century, to witness a display of natural resources such as could never have been imagined by those who first grasped at the wealth of the East. Russia, India, China, Japan, and in a less degree Persia, have all developed hidden capabilities and economic possibilities such as must inevitably affect the world's commercial history. In this field the most surprising advance has undoubtedly been made by Russia.

Russian prospects.

In 1875 Russia was astride of the Caspian, but as yet only straining her eyes across the Eastern Turkman deserts. In 1880 she was knocking at the gates of Merv. Five years later she was setting a limit to the northern borders of Afghanistan. To-day she books her passengers from the Caspian to Samarkand by rail, and has completed two sections of a trans-Asiatic line which will link her capital of St. Petersburg with Vladivostok, on the shores of the Pacific. Already one may cross Asia by steam. With these railways have arisen those local commercial developments which support them, and which were awaiting them. Ferghana is once again a garden in Asia, rich in cereals and fruit, and rapidly developing a most important cotton trade. Siberia and the lands of the Amur have been found to be rich beyond all previous conjecture. Here five millions of square miles are inhabited by four million inhabitants, but the tide of immigration has set in with a steady flow which promises soon to adjust the balance. In 1898 400,000 immigrants were numbered, and the numbers are increasing. It is said that "this vast territory, long looked on as a barren waste, is destined to be one of the world's richest and most productive sections." Here wheat ripens with phenomenal rapidity, and in the Irkutsk country the frost period only lasts for 100 days. Transbaikalia and the Usuri regions are essentially fitted for agricultural development, and the wheat production of the empire has already been sensibly increased since the opening of the Central Siberian Railway. Rice is also now largely grown in Russia, its cultivation having commenced about the year 1880. In the Caucasus, Transbaikal, and Turkestan regions, rice is sown in the same way as wheat. The demand for it is increasing throughout European Russia. Rice grown in Asia is shipped uncleaned to the Caspian ports, and there sold to commission agents. In late years the annual export from Baku has amounted to nearly 50,000 tons.

Agricultural wealth of Siberia.

Mineral wealth.

The mineral resources of Western Siberia are boundless. Between Tomsk and Kooznesk lie 23,000 square miles of coal beds as yet untouched. In Eastern Siberia 400 places are known in which gold is to be found, and iron, graphite, and lapis-lazuli deposits are all awaiting development.

Industries.

The industries of Siberia are growing rapidly. Chemicals, sugar, and paper mills are already paying well. Manchuria looks to Russia for the development of its natural wealth. The Ob and the Yenisei both carry their fleets of steamers, and Russian merchantmen are busy on the Pacific between the Usuri coast and Japan. A strange industry has arisen on the Arctic shores of Siberia, where mammoth ivory is found preserved in layers of underground ice. It is collected by the primitive Tangut inhabitants for the market. These people depend for their living on the migrations of animals. They come with the reindeer herds to the Arctic coast in summer, and return to the protection of the southern forests in winter.

Manchuria.

Russian explorations in Manchuria in connexion with the Siberian railway project, no less than English explorations in the upper basin of the Yang-tse, have largely increased our knowledge of the resources of Eastern Asia. Manchuria has been called the Canada of China, and is found capable of increasing largely her capacities for the supply of food stuff and agricultural products in support of that increased population of the north-eastern provinces of China which will attend the development of the great northern coalfields in the province of Shansi, and the collateral industries which will arise therefrom.

Mineral wealth of China.

Although the resources of China in silk, tea, and opium have long been known, and although much further material progress in agriculture is hardly to be expected from a country which has been highly cultivated by a swarming and industrious population throughout historical ages, it is only lately that these vast resources of mineral wealth have been exhibited which require the development of the many railway schemes which have been already floated to give them practical effect. Vast fields of as yet untouched coal and anthracite exist in the northern, western, and central provinces of China. Copper, iron, mercury, silver, lead, and tin are amongst her mineral products, and salt is found in the upper valleys of the Yang-tse-kiang, or Kinsha.

Japan.

The modern history of Japan shows steady progress in scientific and philosophic culture. Her arts and industries have received a certain impetus since the conclusion of the war with China in 1894, but it is chiefly in the direction of that material advancement which now places Japan in the position of an important military and naval power that the end of the 19th century has to regard Japanese progress. Japan already possesses 3420 miles of railway and 562 miles of telephone. Her army includes 125,000 regulars and 407,000 reserves, and her navy 31 warships. (See JAPAN.)

India, Burma, and Ceylon.—No part of the Asiatic continent has been so prolific in contribution to the general wealth of the

Material progress in India.

world as India, and no countries have been so systematically and continuously drained of their wealth as the Eastern possessions of Great Britain. And yet it may be doubted if any century of their chequered history can show a more astonishing record of agricultural and industrial development than the 19th, and especially the concluding decades of it. It is a record which can only be referred to here in sufficient detail to illustrate the part played by India, Burma, and Ceylon in the economy of the Asiatic continent as a whole.

Indian railways.

The main arteries of Indian railway communication connecting Bombay with Calcutta, Calcutta with Lahore in the extreme north-west, together with a part of the Madras system, were already in existence in 1870; but the great north-western network was as yet in its infancy, and the "battle of the gauges" had yet to be fought out ere a continuity of gauge measurement for all the main Indian lines was finally adopted. In 1899 the number of miles open for traffic and under construction was 22,500 and 3568 respectively.

Irrigation.

The advancement of irrigation works has also been notable, especially on the Punjab, where for one million acres that were irrigated in 1868 no less than 5,200,000 were irrigated in 1899.

Agricultural progress.

The result of the increase in the area of production has been a general increase in agricultural products, and a special development of the growth of wheat for exportation. Under the indirect influence of a depreciation of the silver currency of India, the wheat of the Punjab has been lately able to compete successfully with that of other countries in the English markets, and to undersell that of home production.

Tea has lately superseded coffee cultivation in Ceylon, and cocoa has superseded cinchona. Many districts in India have been found suitable for tea growth which in 1880 were still under forest. More than half a million of acres are now taken up with tea industry in India alone.

Forest conservancy.

The conservation of forests has gradually expanded to the dimensions of a state department with most gratifying results. Out of the 960,000 square miles which constitute British India (apart from the native states) 114,000 square miles are now under the control of the Forest Department. The exports from India to foreign ports amount to over 64,000 tons of teak wood alone, and the forest revenue is yearly expanding. Many special woods from Burma have found their special application in England, and the forests of Burma (as yet undeveloped) promise to be a fruitful source of future revenue. (See INDIA and BURMA.)

Geological and mineral developments.

The recent researches of the Geological Survey of India have proved that country to be rich in mineral wealth. Vast areas known to be covered with rocks that are the matrix of gold, copper, lead, tin, iron, coal, salt, oil, &c., have been mapped out, and actual mining operations on many of these areas have proved that the geologists are not mistaken. Since 1890 the coal production of India has increased from a million and a half to four million tons per annum. Enormous tracts of country are auriferous; but of these all that is being worked is one small patch in Mysore, and yet from this patch gold to the value of 222 lakhs of rupees (a million and a half sterling) was mined in 1899. Petroleum to the extent of 19 million gallons was extracted in the same year, chiefly from the Burma oil wells. The salt mines of the Punjab yielded 66,000 tons of rock salt. Mica to the value of £85,000 was exported from the mines at Hazaribagh, and rubies worth £50,000 to £60,000 were removed from the gem-bearing strata of Mogok (Burma). The mining industry of India is still in its infancy, and yet it employs 263,000 persons, and turns out material to the value of three millions per year. This development of the mineral resources of India is of very recent date, and yet but a fractional part of the vast deposits of coal, gold, and other minerals has been touched. New industrial developments in many other directions remain to be recorded. (See INDIA.)

The Political Geography of Asia.

Southern boundary of Russia in Asia.

The period since 1875 has been an era of boundary-marking in Asia, of defining the politico-geographical limits of empire, and of determining the responsibilities of governments. Russia, Persia, Afghanistan, Baluchistan, India, and China have all revised their borders, and with the revision the political relations between these countries have acquired a new and more assured basis.

The advance of Russia to the Turkman deserts and the Oxus demanded a definite boundary between her trans-Caspian conquests and the kingdom of Afghanistan. This was determined on the north-west by the Russo-Afghan Boundary Commission of 1884-86. A boundary was then fixed between the Hari Rud (the river of Herat), and the Oxus, which is almost entirely artificial in its construction. Zulfikar, where the boundary leaves the Hari Rud, is about 70 miles south of Sarakhs, and the most southerly point of the boundary (where it crosses the Kushk) is about 60 miles north of Herat. From the junction of the boundary with the Oxus at Khamiab, about 150 miles above the crossing-point of the Russian Trans-Caspian railway at Charjai, the main channel of the Oxus river becomes the northern boundary of Afghanistan, separating that country from Russia, and so continues to its source in Victoria Lake of the Great Pamir. Beyond this point the Anglo-Russian Commission of 1895 demarcated a line to the snowfields and glaciers which overlook the Chinese border. Between the Russian Pamirs and Chinese Turkestan the rugged line of the Sarikol range intervenes, the actual dividing line being still indefinite. Beyond Kashgar the southern boundary of Siberia follows an irregular course to the north-east, partly defined by the Tian-Shan and Alatau mountains, till it attains a northerly point in about 53° N. lat. marked by the Sayan range to the west of Irkutsk. It then deflects south-east till it touches the Kunlon affluent of the Amur river at a point which is shown in unofficial maps as in about 117° 30′ E. long. and 49° 20′ N. lat. From here it follows this affluent to its junction with the Amur river, and the Amur river to its junction with the Usuri. It follows the Usuri to its head (its direction now being a little west of south), and finally strikes the Pacific Coast on about 42° 30′ N. lat. at the mouth of the Tumen river 100 miles south of the Amur bay, at the head of which lies the Russian port of Vladivostok. At two points the Russian boundary nearly approaches that of provinces which are directly under British suzerainty. Where the Oxus river takes its great bend to the north from Ishkasham, the breadth of Afghan territory intervening between that river and the main water-divide of the Hindu Kush is not more than 10 or 12 miles; and east of the Pamir extension of Afghanistan, where the Beyik Pass crosses the Sarikol range and drops into the Taghdumbash Pamir, there is but the narrow width of the Karachukar valley between the Sarikol and the Muztagh. Here, however, the boundary is again undefined. Eastwards of this the great Kashgar depression, which includes the Tarim desert, separates Russia from the vast sterile highlands of Tibet; and a continuous series of desert spaces of low elevation, marking the limits of a primeval inland sea from the Sarikol meridional watershed to the Khinghan mountains on the western borders of Manchuria, divide her from the northern provinces of China. From the Khinghan ranges to the Pacific, south of the Amur, stretch the rich districts of Manchuria, a province which connects Russia with the Korea by a series of valleys formed by the Sungari and its affluents—a land of hill and plain, forest and swamp, possessing a delightful climate, and vast undeveloped agricultural resources. Over this land of promise leading to the sea-girt peninsula of Korea, Russian influence is rapidly extending, as it is also over the western Chinese province of the new dominion, including Kashgar and Sarikol.

Afghan political boundaries.

Coincident with the demarcation of Russian boundaries in Turkestan was that of Northern Afghanistan. From the Hari Rud on the west to the Sarikol mountains on the east her northern limits were set by the Boundary Commissions of 1884-86 and of 1895 respectively. Her southern and eastern boundaries have been further defined by a series of minor commissions, working on the basis of the Kabul agreement of 1893, which lasted for nearly 4 years, terminating with the Mohmand settlement at the close of an expedition in 1897.

The Pamir extension of Afghan territory to the north-east reaches to a point a little short of 75° E. long., from whence it follows the water-divide to the head of the Taghdumbash Pamir, and is thence forward defined by the water-parting of the Hindu Kush. It leaves the Hindu Kush near the Dorah Pass at the head of one of the minor Chitral affluents, and passing south-west divides Kafiristan from Chitral and Bajaor, separates the sections of the Mohmands who are within the respective spheres of Afghan and British sovereignty, and crosses the Peshawar-Kabul route at Landi-Khana. It thus places a broad width of independent territory between the boundaries of British India (which have remained practically, though not absolutely, untouched) and Afghanistan; and this independent belt includes Swat, Bajaor, and a part of the Mohmand territory north of the Kabul river. (See AFGHANISTAN.) The same principle of maintaining an intervening width of neutral territory between the two countries is now definitely established throughout the eastern borders of Afghanistan, along the full length of which a definite boundary has been demarcated to the point where it touches the northern limits of Baluchistan on the Gomul river. From the Gomul Baluchistan itself becomes an intervening state between British India and Afghanistan, and the dividing line between Baluchistan and Afghanistan has been laid down with all the precision employed on the more northerly sections of the demarcation. (See BALUCHISTAN.)

Baluchistan can no longer be regarded as a distinct entity amongst Asiatic nations, such as Afghanistan undoubtedly is. Baluchistan independence demands qualification. There is British Baluchistan *par excellence*, and there is the rest of Baluchistan

Baluchistan.

which exists in various degrees of independence, but which is everywhere subject to British control. British Baluchistan officially includes the districts of Peshin, Sibi, and of Tal-Chotiali. As these districts had originally been Afghan, they were transferred to British authority by the treaty of Gandamak in 1879, although nominally they had been handed over to Kalat forty years previously. Now they form an official province of British Baluchistan within the Baluchistan Agency; and the agency extends from the Gomal to the Arabian Sea and the Persian frontier. Within this agency there are districts as independent as any in Afghanistan, but the political status of the province as a whole is almost precisely that of the native states of the Indian peninsula. The agent to the governor-general of India, with a staff of political assistants, practically exercises supreme control.

Kirman.

The increase of Russian influence on the northern Persian border and its extension southwards towards Sistan have led to the appointment of a British consul at Kirman, the dominating town of Southern Khorassan, directly connected with Mashad on the north; and the acquisition of rights of administration of the Nushki district has secured to Great Britain the trade between Sistan and Quetta by the new Helmund desert route.

Political boundary between France and India.

Whilst British India has so far avoided actual geographical contact with one great European power in Asia on the north and west she has touched another on the east. The Mekong river which limits British interests in Burma limits also those of France in Tongking. The eastern boundaries of Burma are not yet fully demarcated on the Chinese frontier. At a point level in latitude with Mogaung, near the northern termination of the Burmese railway system, this boundary is defined by the eastern watershed of the Neaika, the eastern of the two great northern affluents of the Irrawaddy. Then it follows an irregular course southwards to a position south-east of Bhamo in lat. 24°. It next defines the northern edge of the Shan States, and finally strikes the Mekong river in lat. 21° 45′ (approximately). From that point southwards the river becomes the boundary between the Shan States and Tongking for some 200 miles, the channel of the river defining the limits of occupation (though not entirely of interest) between French and British subjects. Approximately on the parallel of 20° N. lat. the Burmese boundary leaves the Mekong to run westwards towards the Salween, and thereafter following the eastern watershed of the Salween basin it divides the Lower Burma provinces from Siam.

Political boundaries in the Farthest East.

More important, however, than the geographical relationship of Great Britain and France in the wilds of Eastern Burma is that of Great Britain and Russia still farther east. The occupation of Port Arthur by the Russians at the close of the war between China and Japan in 1894 placed Russia in a position favourable for farther strategic developments. A line joining Vladivostok with Port Arthur shuts off Korea from the rest of Asia, dominating the peninsula to the south as effectually as it dominates Manchuria to the north. It further commands the entrance to the Gulf of Pe-cheli, and thus might serve to close the seaward gates of Peking. British occupation of Wei-hai-Wei on the opposite side of the strait connecting the Yellow Sea with the Pe-cheli Gulf ensures the due maintenance of British interests on that coast; but it not only places Great Britain in closer geographical proximity to Russia here than has ever occurred yet in Asiatic history, but this juxtaposition is effected at a point where all the engines of naval warfare might be brought into action at a day's notice.

The following table gives a list of the different political divisions of Asia, classified according as they are independent of European Powers or otherwise, with the approximate area and population:—

I. INDEPENDENT, OR NOMINALLY INDEPENDENT.

Name of Country.	Area in square miles.	Population.
Persia	628,000	9,000,000
Afghanistan	215,500	4,000,000
Arabia	960,000	2,000,000
China:		
(1) China Proper	1,336,850	386,000,000
(2) Manchuria	362,310	7,500,000
(3) Mongolia	1,288,000	2,000,000
(4) Tibet	652,000	6,000,000
(5) Dzungaria	147,950	600,000
(6) Turkestan	431,800	580,000
Total Chinese Territories	4,218,910	402,680,000
Japan	152,000	46,500,000
Siam	200,000	5,000,000
Total Independent Asia	6,374,410	469,180,000

II. DEPENDENT TERRITORIES.

Name of Country.	Area in square miles.	Population.
TURKISH SPHERE.		
Asia Minor, Armenia and Kurdistan, Mesopotamia, Syria, &c.	650,000	16,800,000
RUSSIAN SPHERE.		
Caucasus	180,843	9,248,695
Central Asia	1,548,825	7,721,684
Siberia	4,833,496	5,727,100
Bokhara	92,000	2,500,000
Khiva	22,320	700,000
Kwang Tung (Port Arthur)	...	...
Total Asiatic Russia	6,677,484	25,897,479
BRITISH SPHERE.		
British India	964,993	221,172,952
Native States	610,836	65,706,253
Baluchistan	130,000	500,000
Sikkim	28,020	38,458
Andaman and Nicobar Islands	3,135	20,000
Laccadive Islands	80	14,440
Aden	80	41,910
Bahrein Islands	...	25,000
British Borneo	97,000	720,000
Ceylon	25,333	3,009,460
Hong Kong and Kowloon	430	258,000
Straits Settlements and Dependencies	28,000	1,000,000
Wei-Hai-Wei	...	...
Total British Asia	1,887,907	292,506,473
FRENCH SPHERE.		
India	197	279,100
Indo-Chinese Peninsula	363,000	23,000,000
Total French Asia	363,197	23,279,100
GERMAN SPHERE.		
Kiaochow	200	60,000
PORTUGUESE SPHERE.		
India	1,390	495,000
Damao	168	77,450
Indian Archipelago	7,460	300,000
Macao	4	78,630
Total Portuguese Asia	9,022	951,080
DUTCH SPHERE.		
Sumatra, Borneo, Java, Celebes, Molucca, Timor, and smaller islands	584,000	34,000,000
UNITED STATES SPHERE.		
Philippine Islands	115,300	8,000,000
Total Dependent Asia	10,287,110	401,494,132
GRAND TOTAL, ALL ASIA, CONTINENTAL AND INSULAR	16,661,520	870,674,132

The total area of Continental Asia alone is 17,800,000 miles, and its roughly estimated population, 823,000,000.

The Ethnography of Asia.

Although no systematic inquiry into the ethnographical conditions of British Asia has been instituted of late years, collateral information has been acquired during the progress of late political missions and military campaigns which has assisted to illustrate some of the more complex of Asiatic race problems. Within the limits of the continent vast emigrations have taken place periodically, originated partly by the increase of populations in certain districts, and the diminution of food supply in others due to change of climatic conditions; and partly by the lust of conquest, resulting in the irruption of savage hordes into districts already brought under civilized conditions of existence. These irruptions occurred in days when war was not relegated to a portion of the population set apart as the military caste, but when entire nations joined the movement, and their tides swept east and west in fierce currents of swarming humanity for which we can find no parallel later. Combining with the peoples whom they swamped in their course, they have survived in communities all over Southern Asia in conditions so mixed that the problem of individual origin is involved in the greatest entanglement.

The result of trans-border surveys to the north and west of India has been to establish the important geographical fact that it is by two gateways only, one on the north-west and one on the west of India, that the Central Asiatic tides of immigration have flowed into the peninsula. The Kabul valley indicates the north-western entrance, and Makrán indicates that on the west. By the Kabul valley route, which includes at its head the group of passes across the Hindu Kush which extend from the Khawak to the Kaoshán, all those Central Asian hordes, be they Sacæ, Yuebi, Jats, Goths, or Huns, who were driven towards the rich plains of the south, entered the Punjab. Some of them migrated from districts which belong to Eastern Asia, but none of them penetrated into India by eastern passes. Such tides as set towards the Himalaya broke against their farther buttresses, leaving an interesting ethnographical flotsam in the northern valleys; but they never overflowed the Himalayan barrier. And more recently most of the historic invasions of India from Central Asia followed the route which leads directly from Kabul to Peshawur and Delhi.

By the western gates of Makrán prehistoric irruptions from Mesopotamia broke into the plains of Lower Sind, and either passed on towards the central provinces of India or were absorbed in the highlands south of Kalat. In later centuries the Arabs from the west reached the valley of the Indus by this western route, and there established a dynasty which lasted for 300 years. The identification of existing peoples with the various Scythic, Persian, and Arab races who have passed from High Asia into the Indian borderland, has opened up a vast field of ethnographical inquiry which has hardly yet found adequate workers for its investigation. To such fields may be added the yet more complicated problems of those reflex waves which flowed backwards from India into the border highlands.

By far the greater part of the population of Asia is Mongolian. In the form of nomadic and comparatively peaceful communities they extend through the ice-bound steppes of Siberia and the sterile sands of the central deserts to the plains north of the Caspian, and through Eastern Asia, China, and Tibet to Burma and Northern India. We now know that to the Tibeto-Chinese modifications of the pure Mongolian type all the Eastern Burmese tribes—Chins, Kachins, Shans, &c.—belong (as indeed do the Burmese themselves), and that a cognate race occupies the Himalaya to the eastern limits of Kashmir.

Some new light has been thrown on the connexion between the Tibetan race and certain tribes of Central India, the Bhils and Kôls; and it seems more probable that these tribes are the remnants of a Mongolian race which first displaced a yet earlier Negroid population, and was then itself shouldered out by a Caucasian irruption, than that they entered India by any of the northern passages within historic times. Mongolian settlements have lately been found very much farther extended into the border countries of North-west India than has been hitherto recognized. The Mingals, who, conjointly with the Brahuis, occupy the hills south of Kalat to the limits of the Rajput province of Lus Bela, claim Mongolian descent, and traces of a Mongolian colony have been found in Makrán.

Considerable progress has been made in the classification of the various races which occupy the continent to the west of the great Mongolian region. The ancient Sacæ, or Scyths, are now recognized in the Aryan population, who may be found in great numbers and in their purest form in the more inaccessible mountains and glens of the central highlands. These Tajiks (as they are usually called) form the underlying population of Persia, Baluchistan, Afghanistan, and Badakshan, and their language (in the central districts of Asia) is found to contain words of Aryan or Sanskrit derivation which are not known in Persian. They have been for the most part dispossessed of their country by Turkish immigration and conquests, but they still retain their original intellectual superiority over the Turkish and other mixed tribes by which they are surrounded. Uzbeks and Kirghiz have but small affinity with the Mongol element of Asia. They are the representatives of those countless Turkish irruptions which have taken place through all history. Of the two divisions (Kara Kirghiz and Kassak Kirghiz) into which the Kirghiz tribes are divided by Russian authorities, the Kassak Kirghiz is the more closely allied to the Mongol type; the Kara Kirghiz, who are found principally in the valleys of the Tian-Shan and Altai mountains, being unmistakably Turkish. The Kipchaks are only a Kirghiz clan. The language of the Kirghiz is Turki and their religion that of Mahommed. As a nomadic people they have great contempt for the Sarts, who represent the town dwellers of the tribe. The Kalmuks are a Buddhist and Mongolian people who originated in a confederacy of tribes dwelling in Dzungaria, migrated to Siberia, and settled on the Lower Volga. From thence they returned late in the 18th century to the reoccupation of their old ground in Kuldja under the Chinese. The Turkman is the purest form of the Turk element, and his language is the purest form of the Turkish tongue, which is represented at Constantinople by a comparatively mongrel, or mixed, dialect. Recent ethnographers have traced a connexion between the Turkman of Central Asia and the Teutonic races of Europe, based on a similarity of national customs and immemorial usage. Evidence of an original affinity between Turkman and Rajput has also been found in the mutual possession by these races of a ruddy skin, so that as ethnographical inquiry advances the Turk appears to recede from his Mongolian affinities and to approach the Caucasian. Turks and Mongols alike were doubtless included under the term Scyth by the ancients, and as Tatars by more modern writers, insomuch that the Turkish dynasty at Delhi, founded by Babar, is usually termed the Mogul dynasty, although there can be no distinction traced between the terms Mogul and Mongol. The general results of recent inquiry into the ethnography of Afghanistan is to support the general correctness of Bellew's theories of the origin of Afghan races. The claim of the Durani Afghan to be a true Ben-i-Israel is certainly in no way weakened by any recent investigation. The influence of Greek culture in Northern India is now fully recognized, and the distribution of Greek colonies previous to Alexander's time is attested by recent practical knowledge of the districts they were said to occupy. The *habitat* of the Nysaeans, and the identity of certain tribes of Kafiristan with the descendants of those pre-Alexandrian colonists from the west, are also well established. To this day hymns are unwittingly sung to Bacchus in the dales and glens of Kafiristan. The ethnographical status of the mixed tribes of the mountains that lie between Chitral and the Peshawur plains has been fairly well fixed by Biddulph, and much patient inquiry in the vast fields of Baluchistan by Mockler, Tate, and others has resulted in quite a new appreciation of the tribal origin of the great conglomeration of Baluch peoples.

Recent Bibliography of Asia.

The recent bibliography of Asia, including the works of travellers and explorers since 1880, is voluminous. It is impossible to refer to all that has been written in the Survey Reports and Gazetteers of the Government of India, or in the records of the Royal Asiatic Society, or the Asiatic Society, Bengal; but amongst the more important popular works are the following:—

Richthofen. "China, Japan, and Korea," vol. iv. *Jour. R. G. S., China.* Berlin, 1877.—Regel. "Upper Oxus," vol. i. *Proc. R. G. S.*, 1879.—Bellew, Dr. *Afghanistan and the Afghans.* London, 1879.—Prjevalski. "Explorations in Asia." See vols. i. ii. v. ix. and xi. of the *Proc. R. G. S.*, 1879-1889.—Blunt, W. "A Visit to Jebel Shammar," vol. ii. *Proc. R. G. S.*, 1880.—Gill, Captain. *The River of Golden Sand.* London, 1880.—Temple, Sir R. "Central Plateau of Asia," vol. iv. *Proc. R. G. S.*, 1882.—Baker. "A Journey of Exploration in Western Sze-Chuan," vol. i. *Supplementary Papers R. G. S.*, 1882-1885.—Wilson, Sir C. "Notes on Physical and Historical Geography of Asia Minor," vol. vi. *Proc. R. G. S.*, 1884.—Walker, General. "Asiatic Explorers of the Indian Survey," vol. viii. *Proc. R. G. S.*, 1885.—Beal. *Buddhist Records of the Western World.* Boston, 1885.—Doughty. *Travels in Northern Arabia.* Cambridge, 1886.—*Travels in Arabia Deserta.* Cambridge, 1888.—Venukoff. "Explorations," vol. viii. *Proc. R. G. S.*, 1886.—Elias, Ney. "Explorations in Central Asia." See vols. viii. and ix. *Proc. R. G. S.*, 1886-1887.—Carey. "Explorations in Turkestan." See vol. ix. *Proc. R. G. S.*, 1887.—Lansdell. *Through Central Asia.* London, 1887.—Colquhoun. *Report on Railway Connexion between Burma and China.* London, 1887.—Tate, Major C. *Northern Afghanistan.* Edinburgh, 1888.—Younghusband, Capt. F. *The Heart of a Continent.* London, 1893.—*A Journey Through Manchuria, &c.* Lahore, 1888.—Also, see vol. x. *Proc. R. G. S.*, and vol. v. *Jour. R. G. S.*—De Rhins. *L'Asie Centrale.* Paris, 1889.—Bonvalot. *Through the Heart of Asia.* Trans. Pitman. London, 1889.—*From Paris to Tonkin.* Trans. Pitman. London, 1891.—Roborovski. Translation from Russian *Invalide*, Oct. 1889.—Vol. xii. *Proc. R. G. S.*—"Central Asia," vol. viii. *Jour. R. G. S.*, 1896.—Bell, Colonel. "Trade Routes of Asia," vol. xii. *Proc. R. G. S.*, 1890.—Rockhill. "An American in Tibet." *Century Magazine*, Nov. 1890.—*The Land of the Lamas.* London, 1891.—Bent, Theodore. "Hadramut," vol. iv. *Jour. R. G. S.*, 1894.—"Southern Arabia," vol. vi. *Jour. R. G. S.*, 1896.—"Bahrein Islands," vol. xii. *Proc. R. G. S.*, 1890.—Grombchevski. "Explorations in Kuen Lun," vol. xii. *Proc. R. G. S.*, 1890.—Lydekker. "The Geology of the Kashmir Valley and Chamba Territories," vols. xiii. and xiv. *Geological Survey of India.*—Max Müller. *The Sacred Books of the East.* Oxford, 1890-1894.—Reclus, Elisée. *The Earth and its Inhabitants.* (Series) 1890.—Leitner. *Dardistan.*—Blanford, H. F. *Elementary Geography of India, Burma, and Ceylon.* London, 1890.—*Guide to the Climate and Weather of India.* London, 1889.—Dunmore, Lord. *The Pamirs.* London, 1892.—Tissandier, A. *Voyage au tour du Monde.* Paris, 1892.—Curzon, Lord. *Persia and the Persian Question.* London, 1892.—*Russia and the Anglo-Russian Question.* London, 1889.—*Problems of the Far East.* London, 1894.—Bower, Captain. *Diary of a Journey Across Tibet.* Calcutta, 1893.—Szechenyi. *Die Wis-*

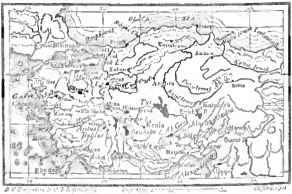
senschaftlichen Ergebnisse der Reise des Grafen Béla Szechenyi in Ostasien. Wien, 1893.—Oldham. "Evolution of Indian Geology," vol. iii. *Jour. R. G. S.*, 1894.—Toll, Baron. "Siberia," vol. iii. *Jour. R. G. S.*, 1894.—Delmar, Morgan. "The Mountain Systems of Central Asia." *Scottish Geological Magazine*, No. 10, of 1894.—Goldsmid. "Persian Geography," vol. vi. *Jour. R. G. S.*, 1895.—Warrington Smyth. "Siam," vol. vi. *Jour. R. G. S.*, 1895.—"Siamese East Coast," vol. xi. *Jour.* 1898.—Kropotkin. "Siberian Railway," vol. v. *R. G. S. Jour.*, 1895.—Lawrence, W. R. *The Vale of Kashmir.* Oxford, 1895.—Vaughan, Captain. "Persia," vol. viii. *Jour. R. G. S.*, 1896.—D'Orleans, Prince H. "Yunan to India," vol. vii. *Jour. R. G. S.*, 1896.—"Tonkin to Talifu," vol. viii. *Jour. R. G. S.*, 1896.—Holdich, Sir T. "Ancient and Mediæval Makrán," vol. vii. *Jour. R. G. S.*, 1896.—Woodthorpe, Colonel. "Shan States," vol. vii. *Jour. R. G. S.*, 1896.—*Report of the Pamir Boundary Commission.* Calcutta, 1896.—Littledale. "Journey Across the Pamirs from North to South," vol. iii. *Jour. R. G. S.*, 1894, and vol. vii. *Jour. R. G. S.*, 1896.—Robertson, Sir G. *The Kafir of the Hindu Kush.* London, 1896.—Stiffe, Captain. "Persian Gulf Trading Centres," vol. viii. ix. and x. *Jour. R. G. S.*, 1897.—Elias & Ross. *A History of the Moghuls of Central Asia, from the Tarikh-i-Rashidi of Mirza Haidar.* London, 1898.—Grenard. *Mission Scientifique sur la Haute Asie.* Paris, 1898.—Sven Hedin, Dr. *Through Asia.* London, 1898.—*Geographie des Hochlandes von Pamir.* Berlin, 1894.—Wellby, Captain. "Through Tibet," *R. G. S. Jour.*, Sept. 1898.—Sykes, Captain. "Persian Explorations," vol. x. *Jour. R. G. S.*, 1898.—Kronshin. "Old Beds of the Oxus," *Jour. R. G. S.*, Sept. 1898.—Hunter, Sir W. *History of British India*, vol. i. London, 1898.—Deasy, Captain. "Western Tibet," vol. ix. *Jour. R. G. S.*, and February and June numbers of *R. G. S. Jour.* for 1899.—Durand, Colonel A. *The Making of a Frontier.* London, 1899.—Cobbold, R. *Innermost Asia.* London, 1900.

(T. H. H.*)

Asia, the first Roman province east of the Ægean, was formed 133 B.C. out of the kingdom left by the will of Attalus, king of Pergamos, to the Romans. It included Mysia, Lydia, Caria, and Phrygia. In 84 B.C., on the close of the Mithradatic war, Sulla reorganized the province, and it was then or later divided into *conventus*. In 27 B.C. it was made a senatorial province under a pro-consul. By the reorganization of Diocletian, A.D. 297, Asia was broken up into several small provinces, and one of these, of which the capital was Ephesus, retained the name of the original province.

Asia Minor, the peninsula on the extreme west of Asia, bounded on the N. by the Black Sea, on the W. by the Ægean, and on the S. by the Mediterranean, and at its N.W. extremity is only parted from Europe by the narrow straits of the Bosporus and Dardanelles. On the E. no natural boundary separates it from the Armenian plateau, but, for descriptive purposes, it will suffice to take a line drawn roughly from the Giaour Dagh, east of the Gulf of Alexandretta, to the Black Sea, east of Trebizond. The term *Anatolia* is sometimes used by geographers as synonymous with Asia Minor; and the same country, excluding Cilicia, is locally called *Rúm*, a name which perpetuates the memory of Rome. The greater portion of Asia Minor consists of a plateau rising gradually from west to east, 2500 feet to 4500 feet, until, east of the Kizil Irmak, the ground rises more sharply to the highlands of Armenia (see Armenia). On the south the plateau is buttressed by the Taurus range, which stretches in a broken irregular line from the Ægean to the Persian frontier. On the north it is supported by a range of varying altitude, which follows the southern coast of the Black Sea and has no distinctive name. On the west the edge of the plateau is broken by broad valleys, and the deeply-indented coast-line throws out long rocky promontories towards Europe. On the north, excepting the deltas formed by the Kizil and Yeshil Irmaks, there are no coast plains, no good harbours except Sinope, and no islands. On the west there are narrow coast plains of limited extent, deep gulfs, which offer facilities for trade and commerce, and a fringe of protecting islands. On the south are the plains of Pamphylia and Cilicia, the almost land-locked harbours of Marmarice and Makri, the broad bay of Adalia, the deep-seated gulf of Alexandretta or Iskanderún, and the islands of Rhodes, Castelorizo, and Cyprus. The *geology* of Asia Minor is imperfectly known. The Taurus range is, for the most part, formed of Cretaceous limestones, and the Black Sea coast range of saccharine limestones, mica schists, and metamorphic rocks. The interior is partly occupied by a vast plain of Tertiary lacustrine formation; igneous rocks are found in nearly every part of the peninsula. In the south-west, serpentine occurs; round Kúla and in the Phrygian monument country there are extensive volcanic deposits; and in the north-west there are granites and various forms of trachyte. In the south-east a remarkable series of volcanic mountains, apparently of the Tertiary period, stretches from Mount Argæus to Kara Dagh, and around them are soft volcanic rocks in which dwelling-places have been cut from a remote period.

Mountains.—The Taurus range, perhaps the most important feature in Asia Minor, attains in Lycia altitudes of 9800 and 10,500 feet, and in the Bulgar Dagh of 8000 and 9000 feet. East of the Bulgar Dagh the continuity of the range is broken by the Sihún and Jihún, and their tributaries. The principal passes across the range are those over which Roman or Byzantine roads ran:—From Laodicea to Adalia; from Apamea or from Pisidian Antioch to Adalia; from Laranda to Germanicopolis, and thence to Anemourium or Kelenderis; from Laranda to Claudiopolis, and thence to Kelenderis or Seleuceia; from Iconium or Cæsarea-Mazaca through the Cilician Gates to Tarsus; from Cæsarea over Anti-Taurus to the valley of the Sarus, and thence to Flaviopolis on the Cilician Plain; from Cæsarea over Anti-Taurus to Kokusos, and thence to Germanicia. Large districts on the southern slopes of the Taurus chain are covered with forests of oak and fir, and there are numerous "yailas" or "alps," with abundant pasturage, to which villagers and nomads move with their flocks during the summer months. Anti-Taurus is the line of heights and mountain peaks which separates the waters running to the Black Sea and the Anatolian plateau from those falling to the Persian Gulf and the Mediterranean. It has its origin in the high land, near the source of the Kizil Irmak, and thence runs south-west to the volcanic district of Mount Argæus. Here it loses its distinctive character, but southwards it terminates in the lofty sharp-peaked ridge of Ala Dagh. South of Sivas a line of bare hills connects Anti-Taurus with a range of high forest-clad mountains, which loses itself southwards in the main mass of Taurus. This range, held to be the true Anti-Taurus by some geographers, throws off, in the latitude of Kaisaríeh, a third, the Binboa Dagh, which separates the waters of the Sihún from those of the Jihún. The principal passes are those followed by the old roads:—From Sebasteia to Tephrike and the Euphrates; from Sebasteia to Melitene; and from Cæsarea to Arabissus. The range of Amanus (Giaour Dagh) is sharply separated from the mass of Taurus by the deep gorge of the Jihún, whence it runs S.S.W. to Rás el-Khanzír, forming the limit between Cilicia and Syria. It attains its greatest altitude in Kaya Duldul, 6500 feet, which rises abruptly from the bed of the Jihún, and it is crossed by two celebrated passes—the Amanides Pylæ (Bagheche Pass), through which ran the road from the Cilician Plain to Apamea-Zeugma, on the Euphrates; and the Pylæ Syriæ (Beilan Pass), through which passed the great Roman highway from Tarsus to Syria. On the western edge of the plateau several short ranges, running approximately east and west, rise above the general level:—Salbakus-Kadmus, 8000 feet; Messogis, 3600 feet; Tmolus, 4000 feet; Dindymus, 8200 feet; Ida, 5800 feet; and the Mysian Olympus, 7600 feet. The valleys of the Mæander and Hermus facilitate communication between the plateau and the Ægean, and the descent from Dorylæum to the Sea of Marmora presents no difficulties. The northern buttress of the plateau is formed by a succession of forest-clad mountain ranges, which have a general east and west direction, and rise progressively as they approach the interior until they culminate in the Galatian Olympus, 8200 feet. East of the Kizil Irmak, although the ground is in places over 7000 feet high, there is no distinct mountain chain. The best routes from the plateau to the Black Sea are those followed by the Roman roads from Tavium and Sebasteia to Amisus. Several minor ranges rise above the level of the plateau, and in its south-east quarter groups of volcanic peaks and cones extend for about 150 miles from Kaisarieh to Karaman. The most important are M. Argæus, 13,100 feet; Ali Dagh, 6200 feet; Hassan Dagh, 8000 feet; Karaja Dagh; and Kara Dagh, 7500 feet. The centre of the plateau is occupied by a vast treeless plain, the Axylon of the Greeks, in which lies a large salt lake, Tuz Geul. The plain is fertile where cultivated, fairly supplied with deep wells, and in many places covered with good pasture. Enclosed between the Taurus and Amanus ranges and the sea is the fertile plain of Cilicia, consisting in great part of a rich, stoneless loam, out of which rise rocky crags that are crowned with the ruins of Greco-Roman and Armenian strongholds.



SKETCH MAP OF ASIA MINOR.

Rivers.—The rivers of Asia Minor are of no great importance. Some do not flow directly to the sea; others find their way to the coast through deep rocky gorges, or are mere torrents; and a few only are navigable for boats for short distances from their mouths. The most important rivers which flow to the Black Sea are:—the Iris (Yeshil Irmak), with its tributaries the Lycus (Kelkit Irmak), which rises on the Armenian plateau, the Chekerek Irmak, which has its source near Yuzgat, and the Tersakan Su. The Halys (Kizil Irmak), the largest river in Asia Minor, with its tributaries the Delije Irmak, Cappadox, which flows through the eastern part of Galatia, and the Geuk Irmak, which has its sources in the mountains above Kastamúni. With the exception of Sivas, no town of importance lies in the valley of the Kizil Irmak throughout its course of over 600 miles. The Sangarius (Sakaría) rises in the Phrygian mountains and, after many changes of direction, falls into the Black Sea, about 80 miles east of the Bosporus. Its tributaries are the Pursak Su (Tembris), which has its source in the Murad Dagh, and, after running north to Eski-shehr, flows almost due east to the Sakaría, and the Enguri Su, which joins the Sakaría a little below the junction of the Pursak. To the Black Sea, about 40 miles east of Eregli, also flows the Billæus (Filiyas Chai). Into the Sea of Marmora run the Rhyndacus (Edrenos Chai), and the Macestus (Susurlu Chai), which unite about 12 miles from the sea. The most celebrated streams of the Troad are the Granicus (Bigha Chai) and the Scamander (Mendere Su), both rising in Mount Ida (Kaz Dagh). The former flows to the Sea of Marmora; the latter to the Dardanelles. The most northerly of the rivers that flow to the Ægean is the Caicus (Bakir Chai), which runs past Soma, and near Pergamos, to the Gulf of Chanderli. The Hermus (Gediz Chai) has its principal sources in the Murad Dagh, and, receiving several streams on its way, runs through the volcanic district of Katakekaumene to the broad fertile valley through which it flows past Manisa to the sea, near Lefke. So recently as about 1880 it discharged into the Gulf of Smyrna, but the shoals formed by its silt-laden waters were so obstructive to navigation that it was turned back into its old bed. Its principal tributaries are—the Phrygius (Kúm Chai), which receives the waters of the Lycus (Geurduk Chai), and the Cogamus (Kuzu Chai), which in its upper course is separated from the valley of the Mæander by hills that were crossed by the Roman road from Pergamos to Laodicea. The Caystrus (Kuchuk Mendere) flows through a fertile valley between M. Tmolus and Messogis to the sea near Ephesus, where its silt has filled up the port and advanced the coast-line between 2 and 3 miles. The Mæander (Mendere Chai) takes its rise in a celebrated group of springs near Dineir, and after a winding course enters the broad valley, through which it meanders to the sea. Its deposits have long since filled up the harbours of Miletus, and converted the islands which protected them into mounds in a swampy plain. Its principal tributaries are the Glaucus, the Senarus (Banaz Chai), and the Hippurius, on the right bank. And on the left bank are the Lycus (Churuk Su), which flows westwards by Colossæ through a broad open valley that affords the only natural approach to the elevated plateau; the Harpasus (Ak Chai), and the Marsyas (China Chai). The rivers that flow to the Mediterranean, with two exceptions, rise in Mount Taurus, and have short courses, but in winter and spring they bring down large bodies of water. In Lycia are the Indus (Gereniz Chai), and the Xanthus (Eshen Chai). The Pamphylian plain is traversed by the Cestrus (Ak Su), the Eurymedon (Keupri Su), and the Melas (Menavgat Chai), which, where it enters the sea, is a broad, deep stream, navigable for about 6 miles. The Calycadnus (Geuk Su) flows south-east, near Mut, and enters the sea a deep rapid river about 12 miles below Selefke. West of Mut it is joined by a large stream which runs below Ermenek. The Cydnus (Tersus

Chai) is formed by the junction of three streams that rise in Mount Taurus, and one of these flows through the narrow gorge known as the Cilician Gates. After passing Tarsus, the river enters a marsh which occupies the site of the ancient harbour. The Cydnus is liable to floods, and its deposits have covered Roman Tarsus to a depth of 20 feet. The Sarus (Sihún) is formed by the junction of the Karmalas (Zamanti Su), which rises in the Uzún Yaila, and the Sarus (Saris), which has its sources in the hills to the south of the same plateau. The first, after entering Mount Taurus, flows through a deep chasm walled in by lofty precipices, and is joined in the heart of the range by the Saris. Before reaching the Cilician Plain the river receives the waters of the Kerkhun Su, which cuts through the Bulgar Dagh, and opens a way for the roads from the Cilician Gates to Konia and Kaisarieh. After passing Adana, to which point small craft ascend, the Sihún runs south-west to the sea. There are, however, indications that at one period it flowed south-east to the Pyramus. The Pyramus (Jihún) has its principal source in a group of large springs near Albistan; but before it enters Mount Taurus it is joined by the Sogutli Irmak, the Khurman Su, and the Genk Su. The river emerges from Taurus, about 7 miles west of Marash, and here it is joined by the Ak Su which rises in some small lakes south of Taurus. The Jihún now enters a remarkable defile which separates Taurus from the Giaour Dagh, and reaches the Cilician Plain near Budrúm. From this point it flows west, and then south-west past Missis, until it makes a bend to discharge its waters south of Ayas Bay. The river is navigable as far as Missis. In the central and southern portions of the plateau the streams either flow into salt lakes, where their waters pass off by evaporation, or into freshwater lakes, which have no visible outlets. In the latter cases the waters find their way beneath Taurus in subterranean channels, and reappear as the sources of rivers flowing to the coast. Thus the Ak Geul supplies the Cydnus, and the Beishehr, Egirdir, and Kestel lakes the rivers of the Pamphylian Plain.

Lakes.—The salt lakes are Tuz Geul, which lies in the great central plain, and is about 60 miles long and 10 to 30 miles broad; Buldur Geul, 2900 feet above sea-level; and Aji-tuz Geul, 2600 feet. The sweetwater lakes are Beishehr Geul, 3770 feet, a fine sheet of water 30 miles long, which discharges south-east to the Soghla Geul; Egirdir Geul, 2850 feet, which is 30 miles long, and noted for the abundance and variety of its fish. In the north-west portion of Asia Minor are Isnik Geul, Abulliont Geul, and Maniyas Geul.

Springs.—Asia Minor is remarkable for the number of its thermal and mineral springs. The most important are:—Yalova, in the Ismid sanjak; Brúsa, Chitli, Terje, and Eski-shehr, in the Brúsa; Tuzla, in the Karasi; Cheshme, Ilija, Hierapolis, and Ala-shehr, in the Aidin; Terzili Hammam, in the Angora; Boli and Iskelib, in the Kastamúni; and Khavsa, in the Sivas viláyet.

The *climate* is varied, but systematic observations are wanting. On the plateau the winter is cold, and in the northern districts there is much snow. The summer is very hot, but the nights are usually cool. On the north coast the winter is cold, and the winds, sweeping across the Black Sea from the steppes of Russia, are accompanied by torrents of rain and heavy falls of snow. East of Samsún, where the coast is partially protected by the Caucasus, the climate is more moderate. In summer the heat is damp and enervating, and, as Trebizond is approached, the vegetation becomes almost subtropical. On the south coast the winter is mild, with occasional frosts and heavy rain; the summer heat is very great. On the west coast the climate is moderate, but the influence of the cold north winds is felt as far south as Smyrna, and the winter at that place is colder than in corresponding latitudes in Europe.

The mineral wealth of Asia Minor is very great, but few mines have yet been opened. The minerals known to exist are—alum, antimony, arsenic, asbestos, boracide, chrome, coal, copper, fuller's earth, gold, iron, kaolin, lead, lignite, magnetic iron, manganese, meerschaum, nickel, rock-salt, silver, sulphur, and zinc. The vegetation varies with the climate, soil, and elevation. The mountains on the north coast are clothed with dense forests of pine, fir, cedar, oak, beech, &c. On the Taurus range the forests are smaller, and there is a larger proportion of pine. On the west coast the ilex, plane, oak, valonea oak, and pine predominate. On the plateau willows, poplars, and chestnut trees grow near the streams. On the south and west coasts the fig and olive are largely cultivated. The vine yields rich produce everywhere, except in the higher districts. The apple, pear, cherry, and plum thrive well in the north; the orange, lemon, citron, and sugar-cane in the south; styrax and mastic in the south-west; and the wheat lands of the Sivas viláyet can hardly be surpassed. The most important vegetable productions are—cereals, cotton, gum tragacanth, liquorice, olive oil, opium, rice, saffron, salep, tobacco, and yellow berries. Silk is produced in large quantities in the vicinity of Brúsa and Amasia. The wild animals include bear, boar, chamois, fallow, red and roe deer, gazelle, hyæna, ibex, jackal, lynx, moufflon, panther, wild sheep, and wolf. Amongst the domestic animals are the buffalo, the Syrian camel, and a mule camel, bred from a Bactrian sire and Syrian mother. Large numbers of sheep and Angora goats are reared on the plateau, and fair horses are bred on the Uzún Yaila; but no effort is made to improve the quality of the wool and mohair, or the breed of horses. Good mules can be obtained in several districts, and small hardy oxen are largely bred for ploughing and transport. The larger birds are the bittern, great and small bustard, eagle, francolin, goose; giant, grey, and red-legged partridge; pelican, pheasant, stork, and swan. The rivers and lakes are well supplied with fish, and the mountain streams abound with trout.

History.—Asia Minor owes the peculiar interest of its history to its geographical position. "Planted like a bridge between Asia and Europe," it has been from the earliest period a battle-ground between the east and the west. The central plateau, 2500 to 4500 feet above the sea, with no navigable river and few natural approaches, with its monotonous scenery and severe climate, is a continuation of Central Asia. The west coast, with its alternation of sea and promontory, of rugged mountains and fertile valleys, its bright and varied scenery, and its fine climate, is almost a part of Europe. These conditions are unfavourable to permanence, and the history of Asia Minor is that of the march of hostile armies, and the rise and fall of small states, rather than that of a united state under an independent sovereign. At a very early period Asia Minor appears to have been occupied by non-Aryan tribes or races which differed little from each other in religion, language, and social system. Since 1875 much light has been thrown upon one of these races—the "Hittites" or "Syro-Cappadocians," who, after their rule had passed away, were known to Herodotus as "White Syrians," and whose descendants can still be recognized in the villages of Cappadocia.[1] The centre of their power was Boghaz Keui (Pteria), east of the Halys, whence roads radiated to the harbours on the Ægean, to Sinope, to Northern Syria, and to the Cilician Plain. Their strange sculptures and inscriptions have been found at Boghaz Keui, Euyuk, Fraktin, Ivriz, and other places between Smyrna and the Euphrates (see Hittites, in the ninth edition of this work). When the great Aryan immigration from Europe commenced is unknown, but it was dying out in the 11th and 10th centuries B.C. In Phrygia the Aryans founded a kingdom, of which traces remain in various rock tombs, forts, and towns, and in legends preserved by the Greeks. The Phrygian power was broken in the 9th or 8th century B.C. by the Cimmerians, who entered Asia Minor through Armenia; and on its decline rose the kingdom of Lydia, with its centre at Sardis. A second Cimmerian invasion almost destroyed the rising kingdom, but the invaders were expelled at last by Alyattes, 617 B.C. The last king, Crœsus, 560-546 B.C., carried the boundaries of Lydia to the Halys, and subdued the Greek colonies on the coast. The date of the foundation of these colonies cannot be fixed; but at an early period they formed a chain of settlements from Trebizond to Rhodes, and by the 8th century B.C. some of them rivalled the splendour of Tyre and Sidon. Too jealous of each other to combine, and too demoralized by luxury to resist, they fell an easy prey to Lydia; and when the Lydian kingdom ended with the capture of Sardis by Cyrus, 546 B.C., they passed, almost without resistance, to Persia. Under Persian rule Asia Minor was divided into four satrapies, but the Greek cities were governed by Greeks, and several of the tribes in the interior retained their native princes and priest-dynasts. An attempt of the Greeks to regain their freedom was crushed 500 B.C., but later the tide turned and the cities were combined into a league for defence against the Persians. The weakness of Persian rule was disclosed by the expedition of Cyrus and the Ten Thousand Greeks, 402 B.C.; and in the following century Asia Minor was subdued by Alexander, 334 B.C.

---

[1] The people, Moslem and Christian, are physically one and appear to be closely related to the modern Armenians. This relationship is noticeable in other districts, and the whole original population of Asia Minor has been characterized as Proto-Armenian or Armenoid.

The wars which followed the death of Alexander gave Asia Minor to Seleucus, but none of the Seleucid kings were able to establish their rule over the whole peninsula. Rhodes became a great maritime republic. An independent kingdom was founded at Pergamos, 283 B.C., which gave its name to a school of sculpture, and lasted until Attalus III., 133 B.C., made the Romans his heirs. Bithynia became an independent monarchy, and Cappadocia and Paphlagonia tributary provinces under native princes. In Southern Asia Minor the Seleucids founded Antioch, Apamea, Attaleia, Laodicea, Seleuceia, and other cities as centres of commerce, and some of them afterwards played an important part in the Hellenization of the country and in the spread of Christianity. During the 3rd century, 278-277 B.C., certain Gallic tribes crossed the Bosporus and Hellespont, and established a Celtic power in Central Asia Minor. They were confined by the victories of Attalus I. of Pergamos, *circ.* 232 B.C., to a district on the Sangarius and Halys to which the name Galatia was applied; and after their defeat by Manlius, 189 B.C., they were subjected to the suzerainty of Pergamos (see Galatia).

The defeat of Antiochus the Great at Magnesia, 190 B.C., placed Asia Minor at the mercy of Rome; but it was not until 133 that the first Roman province, Asia, was formed. Errors in policy and in government facilitated the rise of Pontus into a formidable power under Mithradates, who was finally driven out of the country by Pompey, and died 63 B.C. Under the settlement of Asia Minor by Pompey, Bithynia-Pontus and Cilicia became provinces, whilst Galatia and Cappadocia were allowed to retain nominal independence under native kings. A long period of tranquillity followed, during which the Roman dominion grew, and all Asia Minor was divided into provinces. The boundaries were often changed; and about A.D. 297, in Diocletian's reorganization of the empire, the power of the great military commands was broken, and the provinces were made smaller and united in groups called dioceses. A great change followed the introduction of Christianity, which spread first along the main roads that ran north and west from the Cilician Gates, and especially along the great trade route to Ephesus. In some districts it spread rapidly, in others slowly. With its advance the native languages and old religions gradually disappeared, and at last the whole country was thoroughly Hellenized, and the people united by identity of language and religion.

At the close of the 6th century Asia Minor had become wealthy and prosperous; but centuries of peace and over-centralization had affected the *morale* of the people and weakened the central Government. During the 7th century the provincial system broke down, and the country was divided into *themes* or military districts. From 616 to 626 Persian armies swept unimpeded over the land, and Chosroes II. pitched his camp on the shore of the Bosporus. The victories of Heraclius forced Chosroes to retire; but the Persians were followed by the Arabs, who, advancing with equal ease, laid siege to Constantinople, A.D. 668. It almost appeared as if Asia Minor would be annexed to the dominion of the Caliph. But the tide of conquest was stemmed by the iconoclast emperors, and the Arab expeditions, excepting those of Harún er-Rashid, 781 and 806, and of el-Motasem, 838, became simply predatory raids. In the 10th century the Arabs were expelled. They never held more than the districts along the main roads, and in the intervals of peace the country rapidly recovered itself. But a more dangerous enemy was soon to appear on the eastern border.

In 1067 the Seljúk Turks ravaged Cappadocia and Cilicia; in 1071 they defeated and captured the Emperor Romanus, Diogenes; and in 1080 they took Nicæa. One branch of the Seljúks founded the empire of Rúm, with its capital first at Nicæa and then at Iconium. The empire, which at one time included nearly the whole of Asia Minor, with portions of Armenia and Syria, passed to the Mongols when they defeated the sultan of Rúm in 1243, and the sultans became vassals of the Great Khán. The Seljúk sultans were liberal patrons of art, literature, and science, and the remains of their public buildings and tombs are amongst the most beautiful and most interesting in the country. The march of the Crusaders across Asia Minor left no permanent impression. But the support given by the Latin princes to the Armenians in Cilicia facilitated the growth of the small warlike state of Lesser Armenia, which fell in 1375 with the defeat and capture of Leo VI. by the Memlúk sultan of Egypt. The Mongols were too weak to govern the country they had conquered, and the vassalage of the last sultan of Rúm, who died in 1307, was only nominal. On his death the governors of his western provinces drove out the Mongols and asserted their independence. A contest for supremacy followed, which eventually ended in favour of the Osmanli Turks. In 1400 Sultan Bayezid I. held all Asia Minor west of the Euphrates; but in 1402 he was defeated and made prisoner by Timúr, who swept through the country to the shores of the Ægean. On the death of Timúr Osmanli supremacy was re-established after a prolonged struggle, which ended with the annexation by Muhammad II. (1451-81) of Karamania and Trebizond, and the abandonment of the last of the Italian trading settlements which had studded the coast during the 13th and 14th centuries. The later history of Asia Minor is that of the Turkish empire. The most important event was the advance (1832-33) of an Egyptian army, under Ibrahim Pasha, through the Cilician Gates to Konia and Kutaya.

The defeat of the Emperor Romanus (1071) initiated a change in the condition of Asia Minor which was to be complete and lasting. A long succession of nomad Turkish tribes, pressing forward from Central Asia, wandered over the rich country in search of fresh pastures for their flocks and herds. They did not plunder or ill-treat the people, but they cared nothing for town life or for agricultural pursuits, and as they passed onward they left the country bare. Large districts passed out of cultivation and were abandoned to the nomads. The peasants either became nomads themselves or took refuge in the towns or the mountains. The Mongols, as they advanced, sacked towns and laid waste the agricultural lands. Timúr conducted his campaigns with a ruthless disregard of life and property. Entire Christian communities were massacred, flourishing towns were completely destroyed, and all Asia Minor was ravaged. From these disasters the country never recovered, and the last traces of Western civilization disappeared with the enforced use of the Turkish language and the wholesale conversions to Islám under the Osmanli sultans. The large increase of the Greek population in the western districts, the construction of railways, and the growing interests of Germany and Russia, seem, however, to indicate that the tide is again turning in favour of the West.

Population.—None of the conquering races that invaded Asia Minor, whether from the east or from the west, wholly expelled or exterminated the race in possession. The vanquished retired to the hills or absorbed the victors. In the course of ages race distinction has been almost obliterated by fusion of blood; by the complete Hellenization of the country, which followed the introduction of Christianity; by the later acceptance of Islám; and by migrations due to the occupation of cultivated lands by the nomads. It will be convenient here to adopt the modern division into Moslems, Christians, and Jews:—(*a*) *Moslems.* The Turks never established themselves in such numbers as to form the predominant element in the population. Where the land was unsuitable for nomad occupation the agricultural population remained, and it still retains some of its original characteristics. Thus in Cappadocia the facial type of the non-Aryan race is common, and in Galatia there are traces of Gallic blood. The Zeibeks of the west and south-west are apparently representatives of the Carians and Lycians; and the peasants of the Black Sea coast range, of the people of Bithynia, Paphlagonia, and Pontus. Wherever the people accepted Islám they called themselves Turks, and a majority of the so-called "Turks" belong by blood to the races that occupied Asia Minor before the Seljúk invasion. Turkish and Zaza-speaking Kúrds (see KURDISTAN) are found in the Angora and Sivas viláyets. There are many large colonies of Circassians and smaller ones of Noghai Tatars, Georgians, Lazis, Cossacks, Albanians, and Pomaks. East of Boghaz Keui there is a compact population of Kizilbash, who are partly descendants of Shiá Turks transplanted from Persia and partly of the indigenous race. In the Cilician Plain there are large settlements of Ansaríeh who have migrated from the Syrian mountains (see SYRIA). The nomads and semi-nomads are, for the most part, representatives of the Turks, Mongols, and Tatars who poured into the country during the 350 years that followed the defeat of Romanus. Turkomans are found in the Angora and Adana viláyets; Avshars, a tribe of Turkish origin in the valleys of Anti-Taurus; and Tatars in the Angora and Brúsa viláyets; Yuruks are most numerous in the Konia viláyet. They speak Turkish and profess to be Moslems, but have no mosques or imáms. The Chepmi and Takhtaji, who live chiefly in the Aidin viláyet, appear to be derived from one of the early races. (*b*) *Christians.* The Greeks are in places the descendants of colonists from Greece; but most of them belong by blood to the indigenous races. These people became "Greeks" as being subjects of the Byzantine empire and members of the Eastern Church; and at the present day every Turkish subject who belongs to the Orthodox Church is officially a "Greek." On the west coast, in Cappadocia, in Pontus, and in the mining villages, the language is Romaic; on the south coast and in many inland villages it is either Turkish, which is written in Greek characters, or a Greco-Turkish jargon. In and near Smyrna there are large colonies of Hellenes. Armenians are most numerous in the eastern districts, where they have been settled since the great migration that preceded and followed the Seljúk invasion. In Central and Western Asia Minor they are the descendants of colonists from Persia and Armenia (see ARMENIA). (*c*) The *Jews* live chiefly on the Bosporus; and in Smyrna, Brúsa, and other western towns. *Gypsies*—some Moslem, some Christian—are also numerous.

In the absence of trustworthy statistics, only the following rough estimate can be given:—Moslems, 6,800,000; Armenians, 560,000; Greeks, 780,000; other Christians, 45,000; Jews, gypsies, foreigners, &c., 150,000; total, 8,335,000. This does not include the population of the islands—Moslems, 27,500; Greeks, 342,000; other Christians, 3000; Jews and foreigners, 2000; total, 374,500.

Administration.—The modern division of the country and the present system of administration are treated elsewhere (see TURKEY). The modern towns rarely occupy the sites of the ancient cities, a point well brought out by Ramsay (*Hist. Geog.* pp. 82-88). All Turkish subjects who are not Moslems must belong to one of the recognized millets or religious communities—Armenian, Greek, Jewish, Latin, Protestant, &c. The most striking educational feature is the great influence for good exercised by the schools and colleges of the American Board of Missions. The Greeks and Armenians have good schools for both sexes.

The principal *manufactures* are:—Carpets, rugs, cotton, mohair and silk stuffs, soap, wine, and leather. The *exports* are:—Cereals, cotton, cotton seed, dried fruits, drugs, fruit, gall nuts, gum tragacanth, liquorice root, maize, nuts, olive oil, opium, rice, sesame, sponges, storax, timber, tobacco, valonea, walnut wood, wine, yellow berries, carpets, cotton yarn, cocoons, hides, leather, mohair, silk, silk stuffs, rugs, wax, wool, leeches, live stock, minerals, &c. The *imports* are:—Coffee, cotton cloths, cotton goods, crockery, dry salteries, fezzes, glass-ware, haberdashery, hardware, henna, iron-ware, jute, linen goods, manufactured goods, matches, petroleum, salt, sugar, woollen goods, yarns, &c.

Communications.—There are few metalled roads, but on the plateau light carts can pass nearly everywhere. The lines of railway now open are:—(1) From Haidar Pasha to Ismid, Eski-shehr, and Angora, to be extended to Kir-shehr and Kaisaríeh. (2) From Mudánia to Brúsa. (3) From Eski-shehr to Afiún Kara-hissar and Konia. (4) From Smyrna to Manisa, Ala-shehr and Afiún Kara-hissar, with a branch line from Manisa to Soma. These lines are worked by the German *Gesellschaft der Anatolischen Eisenbahn.* (5) From Smyrna to Aidin and Dineir, constructed and worked by an English company. (6) Mersina to Tarsus and Adana. The German company has power to extend its system to Baghdad, but the route by which the line will cross the Taurus has not yet been decided. There are thus two competing routes—one running inland from Constantinople (Haidar Pasha), the other from Smyrna. The first is practically connected with the European railway system;

the second, with the great sea routes from Smyrna to Trieste, Marseilles, and Liverpool. The right to construct all railways in Armenia and north-eastern Asia Minor has been conceded to Russia.

AUTHORITIES.—Since 1870 Asia Minor has been visited by many travellers, who have brought back valuable information; excavations have been carried out at a few places; and special questions have been studied on the spot by qualified explorers. Valuable papers have been published by Anderson, Benndorf, Bent, Crowfoot, Foucart, Headlam, Hicks, Hogarth, Myres, Ramsay, Schuchhardt, Smith, Wilson, &c., in the *Proceedings R. Geog. Society*, *Journ. Hellenic Society*, in MASPERO's *Recueil*, vols. xiv. xv. &c., the American *Journ. of Archæology*, *Journal of Philology*, *Mitt. des kais. d. arch. Inst. Athen. Abth.*, *Bull. de Corr. Hellénique*, *Wiener Vorlegeblätter*, &c. Fuller works are:—CHANTRE, E. *Recherches archéologiques, Mission en Cappadocie.* Paris, 1898.—CLARKE, J. T. "Investigations at Assos" in *Jour. of Archæl. Inst. of America.* Boston, 1882.—CUINET. *La Turquie d'Asie.* Paris, 1890.—DAVIS, E. J. *Anatolica.* Lond., 1874.—*Life in Asiatic Turkey.* Lond., 1879.—HIRSCHFELD. "Vorläufiger Reisebericht" in *Berlin Monatsbericht.* 1879.—HOGARTH, D. G. *Wandering Scholar in the Levant.* Lond., 1896.—HUMANN and PUCHSTEIN. *Reisen in Kleinasien u. Nordsyrien.* Berlin.—HUMANN, K. *Altertümer v. Hierapolis.* Berl., 1898.—*Alter. v. Pergamon* in pubs. Rl. Mus., Berl., 1895.—LANCKORONSKI, C. *Städte Pamphyliens u. Pisidiens.* Vienna, 1890.—MURRAY. *Handbook for Travellers in Asia Minor, &c.* Lond., 1895.—NAUMANN. *Vom Goldenen Horn zu den Quellen des Euphrat.* Munich, 1893.—PERROT and GUILLAUME. *Expln. Archl. de la Galatie.* Par., 1862-72.—PERROT and CHIPIEZ. *Hist. of Art in Phrygia, &c.* Lond., 1892.—RAMSAY, W. M. *Historical Geography of Asia Minor*, in sup. papers, R. G. S., vol. iv.—*Church in the Roman Empire.* Lond., 1893.—*Cities and Bishoprics of Phrygia.* Oxford, 1895.—RECLUS, E. *Nouvelle Geographie*, vol. ix. Paris, 1884.—STERRETT. *Epigraphical Journey in Asia Minor; Wolfe Expedition to Asia Minor.* Boston, Mass., 1888.—TOMASCHEK. "Zur historischen Topographie v. Kleinasien in Mittelalter," in *Sitzungsber. d. Akad. d. Wissensch. in Wien*, 1891.—TOZER. *Turkish Armenia and Eastern Asia Minor.* Lond., 1881.—VON DIEST and ANTON. "Neue Forschungen in nordlichen Kleinasien," in *Ergänzungsheft*, 116. Pet. Mit. Gotha, 1896.—JENSEN. *Hittiter und Armenier.* Strasbourg, 1898.—VON LUSCHAN. *Reisen in südwest. Kleinasien.* 1888.—MASPERO. *Hist. ancienne.* 3 vols.—EARL PERCY. *Notes from a Diary in Asiatic Turkey*, 1898; *Highlands of Asiatic Turkey.* 1901.

Maps.—KIEPERT. *Nouvelle carte générale des provinces asiatiques de l'Empire Ottoman.* Berlin, 1894.—*Specialkarte v. West-Kleinasien*, 1890. (C. W. W.)

Askabad, or ASKHABAD, a town of Russian Central Asia, capital of the Transcaspian province, 345 miles by rail S.E. of Krasnovodsk and 602 from Samarcand, situated in a small oasis of the same name at the foot of the Kopetdagh range. In 1881 it consisted of merely 500 tents, but it has increased rapidly since it became the chief town of the province. It has three Russian churches, one Armenian church, three mosques, a public library, a progymnasium for boys and another for girls, a technical railway school, and several charitable institutions. It has also a daily newspaper, and strikes the traveller by its relatively good hotels and shops. There are several cotton-cleaning works, as also tanneries, brick-works, and "mineral waters" factory. The trade with Persia, Merv, and Khiva is valued at £250,000 a year. The population, 4000 in 1889, was 19,428 in 1897.

Asmara. See ERITREA.

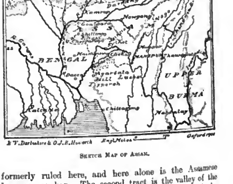
Asnières, a town of France, department of Seine, arrondissement of St Denis, 4 miles S.W. of that town, on the railway to Havre and the river Seine. The town, which has grown rapidly in recent years, is a favourite boating-centre for the Parisians. The industries include the manufacture of bicycles, pianos, trellis-work, perfumery, and boat-building. Population (1881), 10,666; (1896), 23,931, (comm.) 23,931; (1901), 30,881.

Aspen, a city of Colorado, U.S.A., and capital of Pitkin county, situated in the western, mountainous portion of the state, in 39° 12′ N. lat. and 106° 49′ W. long., in the valley of Roaring Fork, a branch of the Grand river. The site of the city is level and its plan is regular. It has two railways, the Denver and Rio Grande and the Colorado Midland. The altitude is 7853 feet. The surrounding country contains many mines, principally of silver, but owing to the depression in the price of this metal, the prosperity of the district has been seriously affected. Population (1890), 5108; (1900), 3303.

Aspinwall. See COLON.

Assab. See ERITREA.

Assam, a province of British India, under the administration of a chief commissioner, situated on the extreme north-east frontier, being almost surrounded on two sides by semi-independent tribes. The administrative headquarters are at the station of Shillong, in the Khasi Hills. Assam is naturally divided into three distinct tracts: first, the valley of the Brahmaputra, from where that river forces its way through the Himalayan range to where it debouches on the plain of Northern Bengal. To this tract alone is the name of Assam strictly applicable, being derived from the Ahom dynasty which formerly ruled here, and here alone is the Assamese language spoken. The second tract is the valley of the Surma or Barak, which is really an extension of the Bengal delta, enclosed by hills on three sides. Between these two valleys lies the third tract, consisting of a series of hill ranges, inhabited by a number of different tribes, entirely unconnected with either the Assamese or the Bengalis. There is still a border line along the north and the east, beyond which only vague political influence is exercised. The Southern Lushai Hills were added to the province in 1898. The numerous democratic chiefs of the Khasi Hills enjoy a certain measure of independence. The native state of Manipur, on the eastern border, is subordinate to Assam. Frontier troubles occasionally arise with the Akas, Daflas, Abors, and Mishmis along the northern border, arising out of raids into British territory. A military expedition had to be sent against the Mishmis in the winter of 1899-1900.



SKETCH MAP OF ASSAM.

Population.—The following table gives the area and population of the several districts of Assam, according to the census of 1891:—

Area and Population of Assam, 1891.

Divisions.	Districts.	Area in Square Miles.	Number of Towns and Villages.	Population, Census of 1891.			Density of Population to Square Mile.
				Males.	Females.	Total.	
Surma Valley .	Cachar Plains	2,472	639	194,373	173,169	367,542	149
	Sylhet	5,414	6,520	1,100,938	1,053,655	2,154,593	398
		7,886	7,159	1,295,311	1,226,821	2,522,135	319
Brahmaputra Valley	Goalpara	3,951	1,100	236,629	215,675	452,304	114
	Kamrup	3,660	1,567	321,029	313,220	634,249	173
	Darrang	3,418	1,117	161,381	146,380	307,761	90
	Nowgong	3,258	910	177,791	166,350	344,141	106
	Sibsagar	2,855	1,309	240,995	216,279	457,274	160
	Lakhimpur	3,724	783	136,404	117,649	254,053	68
		20,869	6,786	1,274,229	1,175,553	2,449,782	117
Hill Districts .	North Cachar	1,728	210	9,306	9,635	18,911	10
	Garo Hills	3,270	1,005	61,313	60,357	121,670	37
	Khasi and Jaintia Hills	6,041	1,330	94,606	103,298	197,904	33
	Naga Hills	5,710	641	62,199	60,668	122,867	21
	North Lushai (civil and military)	3,500	4	2,014	...	2,014	12
	North Lushai (estimated)		25	20,667	20,923	41,590	
		20,219	3,215	250,135	254,881	505,016	25
Grand total		49,004	17,160	2,819,675	2,657,258	5,476,933	112

Since 1881 the population increased by 11 per cent., which cannot be considered a high rate when we take into consideration the large amount of waste land and also the continuous immigration of tea coolies. Classified according to religion, Hindus numbered 2,997,072, or 54·7 per cent. of the total population; Mahommedans numbered 1,483,974, or 27 per cent.; Christians numbered 16,844, or ·31 per cent.; aboriginal tribes numbered 969,765, or 17·7 per cent.; Buddhists numbered 9065, or ·16 per cent.; and "others," 122. The Mahommedans are mostly found in the two old Bengal districts of Sylhet and Goalpara; the Christians in the Khasi and Jaintia Hills, where the Welsh Calvinistic Mission has been most successful. Europeans numbered 1687 and Eurasians 392, leaving 14,765 for native converts.

The provisional figures for the census of 1901 returned the total population of Assam as 6,122,201, including 283,957 for Manipur and 82,344 for the Lushai Hills, neither of which was comprised in the census of 1891. Deducting this additional area, the rate of increase for the province is 6 per cent., compared with 11 per cent. for the previous decennial period. The increase is confined to the tea districts. The lower districts of the Brahmaputra valley, which have suffered severely from a fatal form of fever, show a heavy decrease.

Agriculture.—The greater part of the two districts of Sylhet and Goalpara were permanently settled, with the rest of Bengal. The Brahmaputra valley has a temporary settlement of its own known as *mauzawari*, the average incidence of assessment being about Rs.2 : 8 : 0 per acre. Agricultural statistics are confined to the temporarily settled tract. In 1897-98, out of a total cultivated area of 2,472,734 acres, no less than 1,614,292 acres were under rice, which is everywhere the staple crop, 310,826 acres under tea, and 169,223 acres under mustard. Jute is grown to some extent in Sylhet and Goalpara. The Brahmaputra valley does not produce sufficient rice for its own consumption, large quantities being imported to feed the tea coolies.

Tea Plantations.—Tea is the staple industry of Assam, in both the Brahmaputra and the Surma valleys. The following table shows the progress of the industry at various years between 1883 and 1897 :—

Statistics.

Year.	Area under Mature Plants.	Area under Immature Plants.	Area of Tea Gardens.	Number of Adult Labourers.	Number of Labourers per 100 Acres.
	Acres.	Acres.	Acres.		
1883	161,707	27,746	923,664	153,739	81
1890	200,658	30,380	994,497	250,113	108
1895	234,909	41,105	995,787	334,298	121
1896	247,655	44,254	968,895	366,460	125
1897	263,313	47,337	1,014,017	402,205	129

The following table gives the statistics of the tea industry, according to districts, for 1897, which was not a very prosperous year :—

District.	Number of Tea Gardens.	Total Area of Gardens.	Area under Mature and Immature Plants.	Total Yield.	Out-turn per Acre.
		Acres.	Acres.	℔	℔
Cachar .	191	282,583	61,190	22,031,593	406
Sylhet .	137	150,614	70,200	26,153,168	474
Khasi Hills .	1	100	30	4,000	133
Goalpara .	3	852	410	140,798	371
Kamrup .	31	18,785	5,873	753,228	132
Darrang .	89	108,067	33,984	11,154,360	407
Nowgong .	50	49,884	12,659	4,019,795	355
Sibsagar .	171	231,475	70,644	24,021,294	391
Lakhimpur .	149	171,657	55,560	18,988,096	399
Total .	822	1,014,017	310,550	107,266,332	408

In 1897 the average price per ℔ was R.0 : 5 : 11 (say 6d.) in the Surma valley, and R.0 : 7 : 8 (say 7½d.) in the Brahmaputra valley. The labour required on the tea gardens is almost entirely imported, as the natives of the province are too prosperous to do such work. The importation of coolies is controlled by an elaborate system of legislation, which provides for the registration of contracts, the medical inspection of coolies during the journey, and supervision over rates of pay, &c., on the gardens. A revised Immigration Act for Assam was passed by the Viceroy's council in March 1901. In 1897 the mean annual strength of the labour force was 630,107, of whom 227,902 were children. The total number of adults at the end of the year was 399,975, of whom 195,287 were women. In 1897 the total immigration was 95,931, compared with 81,115 in the preceding year, and with 36,080 in 1890. This large increase is ascribed mainly to the famine in the recruiting tracts, but partly to the demand for additional labour on the tea gardens. The mortality among the coolies during the journey was high, owing to an outbreak of cholera; and the death-rate on the gardens was also high—41·4 per thousand, compared with 32 in the preceding year.

Minerals.—The mineral products of Assam include coal, petroleum, and limestone. The most valuable coal-mines are at the head of the Brahmaputra valley, in the neighbourhood of Makum, which is connected by railway with Dibrugarh on the river. The coal is the best found in India; it is largely used for local purposes, and is also exported to Bengal. In 1897 the output was 197,499 tons, yielding to the Government a revenue of Rs.33,065. In the same neighbourhood are oil-fields, yielding kerosene and paraffin. In 1897 the output was 222,077 gallons. Coal is also found in the Naga and the Khasi Hills. The limestone of the Khasi Hills is largely exported to Bengal. In 1896-97 the total out-turn was 1,630,000 maunds, yielding to the Government a revenue of Rs.18,000.

Railways.—Assam is still unconnected with the general railway system of India, and the Brahmaputra valley entirely depends upon communications by steamer. The Assam-Bengal railway is intended to run from the seaport of Chittagong to the Surma valley, and thence across the hills to Dibrugarh, at the head of the Brahmaputra valley, with a branch to Gauhati lower down the Brahmaputra. The hill section of this line has been found exceedingly difficult of construction, and extensive damage was done by the earthquake of 1897. This railway is financed by the Government, though worked by a company, and therefore ranks as a state line. Up to the end of 1698 the total length open for traffic was 379 miles; the gross earnings in that year were Rx.130,812, and the working expenses Rx.125,357. There are several short lines of light railway, or tramway, in the province. The most important is the Dibru-Sadiya railway, at the head of the Brahmaputra valley, with a branch to the coal-fields. Its length is 78 miles; in 1898 its gross earnings amounted to Rx.76,141, and the working expenses were Rx.49,894.

Trade.—The external trade of Assam is conducted partly by steamer, partly by native boat, and to a small extent by rail. In the Brahmaputra valley steamers carry as much as 66 per cent. of the exports, and 94 per cent. of the imports. In the Surma valley native boats carry about 43 per cent. of both. In 1897-98 (which was a bad year, owing to the earthquake and a poor tea crop) the total exports were valued at Rs.5,33,00,000, of which Rs.3,13,00,000 came from the Brahmaputra and Rs.2,20,00,000 from the Surma valley. The chief items were tea (Rs.3,52,76,000), rice in the husk, oil-seeds, tea-seed, timber, coal, and jute. The imports (excluding treasure) were valued at Rs.4,04,00,000, of which Rs.2,14,00,000 went to the Brahmaputra and Rs.1,90,00,000 to the Surma valley. The chief items were cotton piece-goods, rice not in the husk, sugar, grain and pulse, salt, iron and steel, tobacco, cotton twist and yarn, and brass and copper. No less than three-fourths of the total trade is conducted with Calcutta. The trans-frontier trade is insignificant; and most of it is conducted with the Bengal state of Hill Tipperah. In 1897-98 the total imports were valued at Rs.6,70,600, and the exports at Rs.8,03,236.

Government.—The administrative staff for the province of Assam consists of a chief commissioner, appointed by the governor-general, who is assisted by a secretary, an assistant-secretary, and a personal assistant; a district and sessions judge for Sylhet, who is also sessions judge for Cachar; a judge and commissioner for the Brahmaputra valley; a conservator of forests; a principal medical officer, who is also sanitary commissioner; a director of public instruction; a director-general of police and jails, who is also inspector-general of registration, commissioner of excise, and superintendent of stamps; a director of land records and agriculture, with an assistant; and thirteen deputy commissioners. The total number of civil and revenue courts is 68, and of criminal courts 102. The total strength of the police force consisted in 1897 of 2833 military police, 2253 civil police, and 8993 rural police. The proportion of civil police was one man to 19 square miles of area and to 2358 of population. The daily average number of prisoners in jail during 1897 was 1499. The total number of municipalities is 14, only one of which (Sylhet) has a population exceeding 10,000. In 1897-98 the aggregate municipal income was Rs.2,51,819, of which Rs.90,186 was derived from rates and taxes, and Rs.88,844 from Government contributions. There are 19 local boards, with an aggregate income of Rs.12,28,181, of which Rs.6,46,000 was derived from rates. Of the expenditure, 64 per cent. was devoted to public works, 18 per cent. to education, and 8 per cent. to medical. In 1897 the military force in Assam consisted of three battalions of Gurkhas, one of which was stationed in Manipur, and one regiment of Bengal infantry. In addition, there are three volunteer corps: the Shillong Rifles (60 strong), the Assam Valley Light Horse (373 strong), and the Surma Valley Light Horse (350 strong).

The net revenue and expenditure of Assam for 1897-98 in tens of rupees (Rx.), distributed under the three heads of imperial, provincial, and local, was as follows—net revenue: imperial, Rx.418,626; provincial, Rx.660,100; local, Rx.63,953; total, Rx.1,140,679. Net expenditure: imperial, Rx.62,517; provincial, Rx.631,488; local, Rx.92,585; total, Rx.786,570. Surplus: imperial, Rx.354,109; provincial, Rx.28,632; local, Rx.–28,632; total, Rx.354,109. During the previous ten years, the gross land revenue increased from Rx.429,939 to Rx.596,123, excise from Rx.210,297 to Rx.278,791, and stamps from Rx.78,683 to Rx.87,051.

Education.—The following table gives the chief statistics of education in Assam for the three quinquennial years, 1886-87, 1891-92, and 1896-97. The figures show steady progress, the rate of increase being considerably higher than for India generally. If we compare the number of pupils with the estimated population of school-going age (15 per cent. of the total population), the increase has been from 9·5 to 12·7 per cent. Taking girls alone, the number at school increased from 5136 in 1891-92 to 8276 in 1896-97, or by no less than 81 per cent.; while the proportion to the female population of school-going age rose from 1·3 to 2·1 per cent. This improvement is mainly due to the Welsh missionaries in the Khasi Hills.

	1886-87.		1891-92.		1896-97.	
	Schools.	Pupils.	Schools.	Pupils.	Schools.	Pupils.
Colleges . .	...	...	...	...	1	27
Secondary schools	111	10,574	112	10,353	137	11,623
Primary schools	1,915	53,801	2,365	66,913	3,046	84,267
Special schools	18	529	25	635	41	743
Private institutions	245	4,826	298	5,737	309	6,881
Total . .	2,289	69,730	2,800	83,638	3,534	103,511

Earthquakes.—Assam is liable to earthquakes. By far the severest shock known is that which occurred on the evening of 12th June 1897. The area of this seismic disturbance extended over North-Eastern India, from Manipur to Sikkim; but the focus was undoubtedly in the Khasi and Garo Hills. In the station of Shillong every masonry building was levelled to the ground. Throughout the country bridges were shattered, roads were broken up like ploughed fields, and the beds of rivers were dislocated. In the hills there were terrible landslips, which wrecked the little Cherrapunji railway and caused 800 deaths. The total mortality recorded was 1542, including two Europeans at Shillong. The damage done to public property is estimated at Rs.50,00,000. On the Assam-Bengal railway alone the cost of repairs was Rs.18,84,000. (J. S. Co.)

Assaying.—In its restricted sense the term assaying is applied to the determination of the amount of gold or silver in ores or alloys; but in this article it will be used in its wider signification, and will include a description of the methods for the quantitative determination of those elements in ores which affect their value in metallurgical operations. It would be impossible to give in detail here all the precautions necessary for the successful use of the methods, and the descriptions will therefore be confined to the principles involved and the general manner in which they are applied to secure the desired results.

Gold and Silver.—Ores containing gold or silver are almost invariably assayed in the dry way; that is, by fusion with appropriate fluxes and ultimate separation of the elements in the metallic form. One of the customs which has grown out of our peculiar system of weights is the form of statement of the results of such an assay. Instead of expressing the amounts of gold and silver in percentages of the weight of ore, they are expressed in ounces to the ton, the ounce being the Troy ounce and the ton that of 2000 avoirdupois pounds. To simplify calculation and to enable the assayer to use the metric system of weights employed in all chemical calculations, the "assay ton" ("A.T."=29·166 grammes) has been devised, which bears the same relation to the ton of 2000 lb avoirdupois that one milligram does to the Troy ounce; when one assay ton of ore is used, each milligram of gold or silver found represents one ounce to the ton.

The assay of an ore for gold or silver consists of two operations. In the first the gold or silver is made to combine or alloy with metallic lead, the other constituents of the ore being separated from the lead as slag. In the second, the lead button containing the gold or silver is cupelled and the resulting gold or silver button is weighed. The second operation has been fully described in the ninth edition of this work (vol. ii. p. 725) and need not be further considered. The first is conducted in one of two ways, known respectively as the crucible method and the scorification method. The crucible method is generally used for ores containing gold in small amounts and for certain classes of silver ores. The amount of ore taken for assay is generally one-half "A.T.," but in very low grade ores one, two, and sometimes even four "A.T.s" are used. In the scorification method one-tenth of an "A.T." is the amount commonly taken. While in both methods the same result is sought, the means employed are quite different. In the scorification method the ore is mixed in the scorifier (a shallow dish of burned clay) with from ten to twenty times its weight of granulated metallic lead (test lead) and a little borax glass, and heated in a muffle, the front of which is at first closed. When the lead melts and begins to oxidize, the lead oxide or litharge, as it is called, combines or dissolves the non-metallic and readily oxidizable constituents of the ore, while the gold and silver alloy with the lead. As the slag thus formed flows off to the sides of the scorifier, the assay clears and the melted metallic lead forms an "eye" in the middle. The door of the muffle is then opened and the current of air which is drawn over the scorifier rapidly oxidizes the lead, while the melted litharge gradually closes over the metal. When the "eye" has quite disappeared the door is closed and the temperature raised to make the slag very liquid. The scorifier is taken from the muffle in a pair of tongs and the contents poured into a mould, the lead forming a button in the bottom while the slag floats on top. When cold, the contents of the mould are taken out and the lead button hammered into the form of a cube, the slag, which is glassy and brittle, separating readily from the metal, which is then ready for cupellation. In the crucible method the ore is mixed with from once to twice its weight of flux, which varies in composition, but of which the following may be taken as a type:—

Sodium bicarbonate	8 parts.
Potassium carbonate	3 ,,
Powdered borax	4 ,,
Flour	1 ,,
Litharge	9 ,,

The mixture is charged into a round clay crucible from 100 mm. to 125 mm. high, and heated either in a muffle or in a crucible furnace at a gradually increasing heat for forty or fifty minutes. At the expiration of this time, when the charge should be perfectly liquid and in a tranquil state of fusion, the crucible is removed from the furnace and the contents are poured into a mould. The resulting lead button hammered into shape and carefully cleansed from slag is ready for the cupel. If the button is too large for cupellation, or if it is hard, it may be scorified either alone or mixed with test lead before cupellation. The character and amount of the flux necessarily depend upon the character of the ore, the object being to concentrate in the lead button all the gold and silver while dissolving and carrying off in the slag the other constituents of the ore. Under the most favourable conditions there is a slight loss of gold and silver in the fusion, the scorification, and the cupellation, both by absorption in the slag and by actual volatilization and absorption in the cupel. In ores containing much copper, this metal is largely concentrated in the lead button, making it hard and necessitating repeated scorifications, and in some cases a preliminary removal of the copper by solution of the ore in nitric acid. This leaves the gold in the insoluble residue, which is filtered off, and the silver in the solution is thrown down by hydrochloric acid. The resulting precipitate of silver chloride is filtered, and the residue and the precipitate are scorified together. Ores containing much arsenic or sulphur are generally roasted at a low heat and the assay is made on the roasted material.

Lead.—The "dry" or fire assay for lead is largely used for the valuation of lead ores, although it is being gradually replaced by volumetric methods. One part of the ore is mixed with from three to five parts of a flux of the following composition:—

Potassium carbonate	40·6 per cent.
Sodium bicarbonate	31·3 ,,
Borax	15·6 ,,
Flour	12·5 ,,

The mixture is charged into a clay crucible and heated for twenty minutes at a good red heat. When the mixture has been in a tranquil state of fusion for a few minutes it is poured into a mould. When cold, the button is hammered, cleaned carefully from slag, and weighed. The proportion is calculated from the amount of ore used, and the result is expressed in parts in a hundred or percentage of the ore. Various impurities, such as copper, antimony, and sulphur, go into the lead button, so that the result is generally too high. The most accurate method for the determination of lead in ores is the gravimetric method, in which it is weighed as lead sulphate after the various impurities have been separated. Nearly all lead ores contain more or less sulphur; and as in the process of solution in nitric acid this is oxidized to sulphuric acid which unites with the lead to form the very insoluble lead sulphate, it is simpler to add sulphuric acid to convert all the lead into sulphate and then evaporate until the nitric acid is expelled. The salts of iron, copper, &c., are then dissolved in water and filtered from the insoluble silica, lead sulphate, and calcium sulphate, which are washed with dilute sulphuric acid. The insoluble matter is treated with a hot solution of alkaline ammonium acetate, which dissolves the lead sulphate, the other materials being separated by filtration. The lead sulphate, re-precipitated in the filtrate by an excess of sulphuric acid and alcohol, is then filtered on an asbestos felt in a Gooch crucible, washed with dilute sulphuric acid and alcohol, ignited, and weighed. Lead sulphate contains 68·30 per cent. of metallic lead.

There are several volumetric methods for assaying lead ores, but the best known is that based on the precipitation of lead by ammonium molybdate in an acetic acid solution. The lead sulphate, obtained as described above and dissolved in ammonium acetate, is acidulated with acetic acid diluted with hot water and heated to boiling-point. A standardized solution of ammonium molybdate is then added from a carefully-calibrated burette. As long as the solution contains lead, the addition of the molybdate solution causes a precipitation of white lead molybdate. An excess of the precipitant is shown by a drop of the solution imparting a yellow colour to a solution of tannin, prepared by dissolving one part of tannin in 300 of water; drops of this solution are placed on a white porcelain plate, and as the precipitant is added to the lead solution a drop of the latter is removed from time to time on a glass stirring-rod and added to one of the drops on the porcelain plate. The appearance of a yellow colour shows that all the lead has been precipitated and that the solution contains an excess of molybdate. From the reading of the burette the lead is calculated. The molybdate solution should be of such a strength that 1 cc. will precipitate 0·01 gramme of lead. It is standardized by dissolving a weighed amount of lead sulphate in ammonium acetate and proceeding as described above.

Zinc.—Chemically the ores of zinc consist of the silicates, carbonates, oxides, and sulphides of zinc associated with other metals, some of which complicate the methods of assay. The most modern and the most generally accepted method is volumetric, and is based on the reaction between zinc chloride and potassium ferrocyanide, by which insoluble zinc ferrocyanide and soluble potassium chloride are formed; the presence of the slightest excess of potassium ferrocyanide is shown by a brownish tint being imparted by the solution to a drop of uranium nitrate. The ore (0·5 gramme) is digested with a mixture of potassium nitrate and nitric acid. A saturated solution of potassium chlorate in strong nitric acid is added, and the mass evaporated to dryness. It is then heated with a mixture of ammonium chloride and ammonia, filtered and washed with a hot dilute solution of the same mixture. The filtrate diluted to 200 cc. is carefully neutralized with hydrochloric acid, an excess of 6 cc. of the strong acid is added, and the solution saturated with hydrogen sulphide, which precipitates the copper and cadmium, metals which would otherwise interfere. Without filtering, the standard solution is added from a burette, and from time to time a drop of the solution is removed on the glass stirring-rod and added to a drop or two of a strong solution of uranium nitrate, previously placed on a white porcelain plate. The appearance of a brown tint in one of these tests shows the end of the reaction. When cadmium is not present the copper may be precipitated by boiling the acidulated ammoniacal solution with test lead and titrating, as before described, without removing the lead and copper from the solution. The ferrocyanide solution is standardized by dissolving 1 gramme of pure zinc in 6 cc. of hydrochloric acid, adding ammonium chloride and titrating as before. This method is modified in practice by the character of the ores, carbonates and silicates free from sulphides being decomposed by hydrochloric acid, with the addition of a little nitric acid.

Copper.—The fire assay for copper ores was abandoned years ago and the electrolytic method took its place; this in turn is now largely replaced by volumetric methods. In the electrolytic method from 0·5 to 5 grammes of ore are treated in a flask or beaker, with a mixture of 10 cc. of nitric and 10 cc. of sulphuric acid, until thoroughly decomposed. When this liquid is cold it is diluted with cold water, heated until all the soluble salts are dissolved, transferred to a tall, narrow beaker, and diluted to about 150 cc. The electrodes are attached to a frame connected with the battery and the beaker is placed on a stool, which can be raised so that the electrodes are immersed in the liquid and reach the bottom of the beaker. The electrodes consist of two cylinders of platinum (placed one inside the other) about 75 mm. high, the smaller of the two 37 mm., and the larger 50 mm. in diameter, both pierced with 10 to 12 holes 5 mm. in diameter, evenly distributed over the surfaces to facilitate diffusion of the liquids. The surfaces of the cylinders are roughened with a sand blast to increase the areas and make the deposited metals adhere more firmly. Each cylinder has a platinum wire fused to the upper circumference to connect with a clamp from which a wire leads to the proper pole of the battery. The smaller cylinder is generally the negative electrode on which the copper is deposited. The framework carrying the clamps is arranged so that a number of determinations may be made at one time, the wires from the clamps running from a rheostat, so arranged that currents of any strength may be used simultaneously. The cylinder, having been carefully weighed, is placed in position, the beaker containing the solution is adjusted, and the current passed until all the copper is precipitated. This generally requires from two to twelve hours. The cylinders are then removed from the solution and washed with distilled water, the one holding the deposited copper being washed with alcohol, dried, and weighed; the increase in weight represents the copper contents of the ore. The deposited copper should be firmly adherent and bright rosy red in colour. Silver, arsenic, and cadmium, if present, are precipitated with the copper and affect the accuracy of the results; they should be removed by special methods.

Volumetric methods are more expeditious and require less apparatus. The potassium cyanide method is based on the fact that, when potassium cyanide is added to an ammoniacal solution of a salt of copper, the insoluble copper cyanide is formed, the end of the reaction being indicated by the disappearance of the blue colour of the solution. One gramme of the ore is treated in a flask with a mixture of nitric and sulphuric acids and evaporated until all the nitric acid is expelled. After cooling a little, water is added, and then a few grammes of aluminum foil free from copper. On this foil the copper in the solution is all precipitated by electrolytic action in a few minutes, and the aluminum is dissolved by the addition of an excess of sulphuric acid. Water is added, and as soon as the gangue and copper particles have settled the clear solution is decanted, and the residue washed several times in the same way. The copper is then dissolved in 5 cc. of nitric acid; if silver is present a drop or two of hydrochloric acid is added, the solution diluted to about 50 cc., and filtered. To the filtrate (or, if no silver is present, to the diluted nitric acid solution) 10 cc. of ammonia are added, and a standard solution of potassium cyanide is run in from a burette until the blue colour has nearly disappeared. The solution is filtered to get rid of the precipitate, and the titration is finished in the nearly clear filtrate, which should be always about 200 cc. in volume. The titration is complete when the blue colour is so faint that it is almost imperceptible after the flask has been vigorously shaken. The potassium cyanide solution is standardized by dissolving 0·5 gramme of pure copper in 5 cc. of nitric acid, diluting, adding 10 cc. of ammonia, and titrating exactly as described above.

When potassium iodide is added to a solution of cupric acetate, the reaction $Cu(C_2H_3O_2)_2 + 2KI = CuI + 2K(C_2H_3O_2) + I$ takes place; that is, for each molecule of copper one molecule of iodine is liberated. If a solution of sodium hyposulphite is added to this solution, hydriodic acid and sodium tetrathionate are formed; and if a little starch solution has been added, the end of the reaction is indicated by the disappearance of the blue colour, due to the iodide of starch. The amount of iodine liberated is therefore a measure of the copper in the solution, and when the sodium hyposulphite has been carefully standardized the method is extremely accurate. The ore is treated as described in the cyanide method until the copper precipitated by the aluminum foil has been washed and dissolved in 5 cc. of nitric acid; then 0·25 gramme of potassium chlorate is added, and the solution boiled nearly dry to oxidize any arsenic present to arsenic acid. The solution is cooled, 50 cc. water added, then 5 cc. ammonia, and the solution is boiled for five minutes. Next 5 cc. of glacial acetic acid are added, the solution cooled, and 5 cc. of a solution of potassium iodide (300 grammes to the litre) and the standard solution of sodium hyposulphite run in from a burette until the brown colour has nearly disappeared. A few drops of starch solution are then added, and when the blue colour has nearly vanished a drop or two of methyl orange makes the end reaction very sharp. The hyposulphite solution is standardized by dissolving 0·3 to 0·5 gramme of pure copper in 3 cc. of nitric acid, adding 50 cc. of water and 5 cc. of ammonia, and titrating as above after the addition of 5 cc. of glacial acetic acid and 5 cc. of the potassium iodide solution.

Iron.—The methods used in the assay for iron are volumetric, and are all based on the property possessed by certain reagents of oxidizing iron from the ferrous to the ferric state. Two salts are in common use for this purpose, potassium permanganate and potassium bichromate. It is necessary in the first place, after the ore is in solution, to reduce all the iron to the ferrous condition; then the carefully standardized solution of the oxidizing reagent is added until all the iron is in the ferric state, the volume of the standard solution used being the measure of the iron contained in the ore. The end of the reaction when potassium permanganate is employed is known by the change in colour of the solution. As the solution of potassium permanganate, which is deep red in colour, is dropped into the colourless iron solution, it is quickly decolourized while the iron solution gradually assumes a yellowish tinge, the first drop of the permanganate solution in excess giving it a pink tint. With potassium bichromate solution, which is yellow, the iron solution becomes green from the chromium chloride or sulphate formed, and the end of the reaction is determined by removing a drop of the solution on the stirring-rod and adding it to a drop of a dilute solution of potassium ferricyanide on a white tile. So long as the solution contains a ferrous salt, the drop on the tile changes to blue; hence the absence of a blue colouration indicates the complete oxidation of all the ferrous salt and the end of the reaction. One gramme of ore is usually taken for assay and treated in a small flask or beaker with 10 cc. of hydrochloric acid. All the iron in the ore generally dissolves upon heating, and a white residue is left. Occasionally this residue contains a small amount of iron in a difficultly soluble form; in that case the solution is slightly diluted with water and filtered into a larger flask. The residue in the filter is ignited and fused with a little sodium carbonate and nitrate, or with sodium peroxide. The product is treated with water, filtered, and the residue dissolved in hydrochloric acid and added to the main solution. This solution, which should not exceed 50 cc. or 75 cc. in volume, contains the iron in the ferric state and is ready for reduction.

In the reduction by metallic zinc, about 3 grammes of granulated or foliated zinc are placed in the flask, which is closed with a small funnel; when the iron is reduced, add 10 cc. of sulphuric acid, and as soon as all the zinc is dissolved the solution is ready for titration. In the reduction by stannous chloride the solution of the ore in the flask is heated to boiling, and a strong solution of stannous chloride is added until the solution is completely decolourized; then 60 cc. of a solution of mercuric chloride (50 grammes to the litre) are run in and the contents of the flask poured into a dish containing 600 cc. of water and 60 cc. of a solution containing 200 grammes of manganous sulphate, 1 litre of phosphoric acid (1·3 sp. gr.), 400 cc. of sulphuric acid, and 1600 cc. of water. The solution is then ready for titration with the standard permanganate solution.

The permanganate or bichromate solution is standardized by dissolving 0·5 of a gramme of pure iron wire in a flask in hydrochloric acid, oxidizing it with a little potassium chlorate, boiling off all traces of chlorine, deoxidizing by one of the methods described above, and titrating with the solution. As the wire always contains impurities, the absolute amount of iron in the wire must be determined and the correction made accordingly. Pure oxalic acid may also be used, which, in the presence of sulphuric acid, is oxidized by the standard solution according to the reaction:—

$$5(H_2C_2O_4 2H_2O) + 3H_2SO_4 + K_2Mn_2O_8 = 10CO_2 + 2MnSO_4 + K_2SO_4 + 18H_2O.$$

The reaction in case of ferrous sulphate is:—

$$10FeSO_4 + K_2Mn_2O_8 + 8H_2SO_4 = 5Fe_2(SO_4)_3 + K_2SO_4 + 2MnSO_4 + 8H_2O;$$

that is, the same amount of potassium permanganate is required to oxidize 5 molecules of oxalic acid that is necessary to oxidize 10 molecules of iron in the form of ferrous sulphate to ferric sulphate, or 63 parts by weight of oxalic acid equal 56 parts by weight of metallic iron. Ammonium ferrous sulphate may also be used; it contains one-seventh of its weight of iron. (A. A. B.)

Assche, a town of Belgium, in the province of Brabant, 8 miles N.W. by W. of Brussels, with a station on the line between Brussels and Termonde. It has breweries and soap-works. Population (communal) (1890), 7063; (1897), 7524.

Assen, a town in the Netherlands, capital of the province of Drenthe, 16 miles S. of Groningen, on the railway Meppel–Groningen of the Netherlands State railways and two canals. Peat-cutting is a considerable industry. In the neighbourhood are situated the megaliths (*Hunebedden*) mentioned by Tacitus, and a large number of prehistoric remains have been discovered. The population in 1898 was 10,964.

Assiniboia. See NORTH-WEST TERRITORIES.

Assinie. See IVORY COAST.

Assisi, a town and bishop's see of the province of Perugia, Umbria, Italy, situated on the slope of Mt. Subasio, 15 miles E. by S. from Perugia by rail, still surrounded by mediæval walls, and celebrated as the birthplace of St Francis, whose tomb, in the crypt (1818) of the church of the Franciscan monastery, attracts crowds of pilgrims every year. This church is a double structure, and consists of an upper church and a lower church, the latter begun in 1228, and both finished in 1253. Both are adorned by frescoes and pictures by Giotto, Cimabue, and others. Down in the valley is the pilgrimage church of Santa Maria degli Angeli, begun by Vignola in 1569 over the oratory of St Francis, and finished about 1640; restored after the earthquake of 1832. It is decorated by works from the brush of the Della Robbias, Overbeck, and others. In the town there are, further, the cathedral, finished in 1140, and remodelled in the interior in 1572, with a marble statue of St Francis by Dupré and a Madonna and saints by Niccolò da Foligno; the new church, built in 1615 on the site of the house in which St Francis was born; and the church of Santa Chiara (1257), containing the remains of St Clara, foundress of the order of the nuns of St Clare (1212). There are also an old castle and the ruins of a Roman amphitheatre. Assisi was also the birthplace of the poet Propertius (between 50 and 44 B.C.). Population, about 7000; of commune, about 17,000.

Assiut, or **Siut,** the administrative capital of Upper Egypt, and the largest and best-built town in the Nile Valley south of Cairo, with a population which rose from 32,000 in 1882 to 42,000 in 1900. It stands near the left bank of the Nile on the Nile Valley railway, of which it is an important station, 248 miles south of Cairo. Here is a large canal communicating during the floods with the Bahr Yusuf, which runs parallel with the Nile, and discharges its overflow into the Fayyum depression. The canal is now skirted by a magnificent embankment planted with shady trees leading from the river to the town. There are several bazaars, baths, and handsome mosques, one noted for its lofty minaret, and here the American mission has established a college for both sexes. Assiut is famous for its red and black pottery, which finds a ready market all over Egypt. In the neighbouring Libyan hills are numerous rock-tombs, where are often found the remains of wolf mummies, this animal having been the tutelar deity of the place, whence its Greek name of *Lycopolis* ("wolf-town").

Assuan, or **Aswan,** a town of Upper Egypt on the right bank of the Nile, facing Elephantine Island below the First Cataract. It is a station on the Nile Valley railway, 590 miles from Cairo. In 1880, though the centre of a flourishing trade with the Sudan and Abyssinia—the annual value of the goods in transit was estimated at £2,000,000—its population was only about 4000. During the reign of the Khalifa it gained importance as the seat of the military government of the frontier provinces extending from Edfu to Wadi Halfa, and numbered some 10,000 inhabitants. After the defeat of the Khalifa at Omdurman it became popular as a winter health-resort, and in 1901 had a population of about 25,000. The great barrage immediately above Aswan will place the agricultural prospects of the surrounding country on an entirely new and improved footing. In connexion with the work upon this undertaking and the reservoirs a town of about 12,000 workmen has sprung into existence. Aswan gives its name to one of the three second-class administrative districts into which the Anglo-Egyptian Sudan was divided in 1899, and is the headquarters of the English military commandant.

Astara, a port on the Caspian, situated in 38° 27′ N. lat. and 48° 53′ E. long., on both sides of the river of the same name, which, according to the Turkmanchai treaty of 1828, is the frontier between Persia and Russia. Until the Mercury Steam Navigation Company made it a port of call, about 1860, it was an unimportant fishing village, but it has now a considerable trade, and much Russian merchandise is landed there and forwarded to Azerbáiján and Tabriz *via* Ardebil, 30 miles south-west. In 1897, 77 vessels (76 steamers), with a tonnage of 43,101, entered the port, and 272 vessels (240 steamers), with a tonnage of 88,011, cleared it.

Asthma. See Pathology (*Respiratory Organs*).

Asti, a town and episcopal see of the province of Alessandria, Piedmont, Italy, on the Tanaro, 22 miles W. from Alessandria by rail. Besides the cathedral, it has the interesting church of St Peter and the church of St John, both assigned to the Longobardic epoch (middle of 8th century, but remodelled in the 10th). There is a statue of Victor Emmanuel. Asti is famous for its wine. Population, about 19,000.

Astoria, a city of Oregon, U.S.A., and capital of Clatsop county, situated on the Columbia, near its mouth, in the north-western part of the state, and has an excellent harbour. It is connected with Portland by the Astoria and Columbia River railway and by steamboat lines. Its industries consist largely in salmon-canning and in the manufacture of lumber, the surrounding country being densely forested with fir, cedar, and hemlock. It was founded in 1811, as a depot in the fur trade, by John Jacob Astor, after whom it is named. It was seized by the British in 1813, but restored in 1818. In 1821, while occupied by the North-West Fur Company, it was burned and practically abandoned, leaving only a few settlers. Population (1880), 2803; (1890), 6184; (1900), 8381.

Astrakhan, a government of S.E. Russia, on the lower Volga. Area, 91,237 sq. miles, of which 6730 sq. miles are in the delta of the Volga and the brackish lagoons, and 62,290 sq. miles covered by the Kalmyk and the Kirghiz Steppes. The climate is very hot and dry, the average temperatures being for the year, 50° Fahr.; for January, 21°; for July, 78°; yearly rainfall, 7·3; often no rain at all in summer. Population (1897), 1,002,316, of whom 485,517 were women, and 132,383 urban. About 132,000 Kalmyks and 260,000 Kirghiz are half nomad. There are besides nearly 44,000 Tatars, 7000 Armenians, 1350 Poles, and as many Jews. The average percentage of births is 5·7, and that of deaths 3·7. Primary education remains at a low level; the total number of pupils in primary schools being only 12,337 (one school for every 2380 inhabitants). Fishing at the mouth of the Volga gives occupation to nearly 30,000 persons, as much as 278,000,000 herrings being caught in a good year. Salt is largely extracted (300,000 tons) from lakes, chiefly at Baskunchak, which is now connected with the Volga by rail. Cattle breeding is an important industry; in 1897 there were 1,075,600 horned cattle, 214,935 horses, and 3,521,000 sheep. Corn is imported, but gardening and the culture of mustard, melons, and fruit for export are on the increase. Agriculture is not much developed, there being (1899) only 1,007,300 acres under cereals, and the total cereal crop being on the average 149,600 tons. Forests cover only 430,000 acres. The Russian railways only touch the borders of the province. The government is divided into five districts, the chief towns of which are—Astrakhan, pop. 113,000; Enotaevsk, 2810; Krasnyi Yar, 4680; Tchornyi Yar, 5140; and Tsarev, 8900. Several villages are very populous, such as Nikolaevskaya Sloboda (17,800). The Kalmyk Steppe (pop. 127,776), and the Inner Kirghiz Horde (213,146), are under their own internal administration. So also is the territory of the Astrakhan Cossacks (pop. 25,600).

Astrakhan, capital of the above, on the left bank of the main branch of the Volga, and 60 miles from the Caspian Sea (68 feet below the level of the ocean) has, since the development of the naphtha industry and the opening of the Transcaspian railway, become a great centre for external and internal trade, the yearly returns of which are estimated at 16,100,000 roubles for the former and 52,157,000 for the latter. The port is visited yearly by about 4000 vessels; and 1242 vessels (90 steamers) belong to it. Population (1867), 47,839; (1897), 113,000. It is well provided with gymnasia for boys and girls and technical schools. Good public gardens and squares (one of which is adorned by a monument to Alexander II.) have been laid out.

Eight miles above Astrakhan, on the right bank of the Volga, are the ruins of two ancient cities, one above the other. In the upper layer, amidst all sorts of debris, charcoal, and bones, have been found gold and silver mints made by the Mongol Horde rulers, as well as various silver and gold ornaments. These ruins are separated by a layer of earth from older and scantier ruins, supposed to be the remains of the large and prosperous city Atel, or Itil (Etel, Idl) of the Arabian geographers (Ibn Foslan, Ibn Haukal, &c.), which was the residence of the Khan of the Khosars, and was destroyed by the Russes in 969. The upper layer of ruins may represent the old city of Balanjar (Balansar, Belender).

(P. A. K.)

ASTRONOMY.

PART I. of the article on ASTRONOMY in the ninth edition of this Encyclopædia treats of the history of the science, and needs no supplement. In the first six chapters of Part II. are developed those general principles and methods which form the basis of the science and are not subject to material revision. Our present purpose is to supplement the chapters from VII. onwards. We shall first treat the recent developments relating to the solar system, and afterwards briefly describe the progress of knowledge in regard to the fixed stars. In arranging the first subject we shall set forth the general results of telescopic and spectroscopic observations of the planets, in advance of results derived from the mathematical investigation of their motions. The subject thus divides itself into three sections:—

I. The physical and other general features of the solar system.

II. Gravitational and theoretical astronomy.

III. The recent development of our knowledge of the fixed stars.

I. PHYSICAL FEATURES OF THE SOLAR SYSTEM.

Improvement in telescopes.

The development of this subject since 1880 is principally due to the increased power of our instruments and the more extended use of the spectroscope. Sixty years ago the spectroscope was unknown, and the telescopes most used were from 4 to 9 inches in aperture. About 1840, the successors of Fraunhofer made two telescopes of 14 inches' aperture for the observatories of Pulkowa and Harvard University. The extreme limit of size was then thought to be attained, but by 1880 the aperture was carried up to 26 inches, and now it is 40 inches. The great Yerkes telescope of the university of Chicago gives about seven times the light of the Harvard and Pulkowa instruments. It might be thought that this enormous increase of power would have resulted in the final settlement of all questions, formerly the subject of debate, as to the physical phenomena presented by the planets. But such is far from being the case, and the vast mass of observations that have been accumulated has thrown less light than might have been expected on the question of the rotation or physical constitution of these bodies, though, at the same time, critical examination may show that the results to be derived are not so discordant or doubtful as might appear from the seeming divergence of the observations themselves. The observers who, since 1880, have made careful studies upon the appearance of the planets in the telescope, are so numerous that only a few of the best known can be mentioned. The systematic work of the British Astronomical Association, which has organized sections for the special study of particular objects, offers a good example of the energy with which a large and popular body may pursue scientific investigation. This body does not, however, command the instruments or enjoy the atmospheric conditions necessary to settle the most difficult questions. Among the individual observers Schiaparelli may be assigned the first place, in view of his long-continued studies of the planets under a fine Italian sky, the conscientious minuteness of his examinations, and his eminence as an investigator. In what concerns the means and opportunities of observation, Barnard at the Lick Observatory enjoyed advantages offered to no other observer. The observatory at Flagstaff, Arizona, was founded by Mr Percival Lowell, of Boston, for the special purpose of studying the physical phenomena presented by the planets, particularly Mars, and its situation is believed to be one of the best as regards atmospheric conditions.

Mercury.

Taking up the planets in order, we begin with Mercury. Only on rare occasions have observers succeeded in discerning any well-defined features on the disc of this planet. Up to 1890 the period of its rotation was generally said to be nearly twenty-four hours, a statement which rested mainly on observations made by Schroeter, the indefatigable observer of Lilienthal, about the beginning of the century. Cautious and conservative astronomers have been more and more sceptical as to the correctness of this period, on account of the failure of observers with better instruments than Schroeter's to see permanent markings that could be followed from day to day. In 1882 Schiaparelli began a careful study of the face of the planet, with a refractor of 8 inches' aperture, subsequently replaced by one of 18 inches'. His unexpected conclusion was that the rotation of Mercury resembles that of the moon, in having its period equal to that of the orbital revolution. As the moon always presents the same face to the earth, so Mercury always presents very nearly the same face to the sun. Schiaparelli also announced that the axis of rotation of the planet is very nearly perpendicular to the plane of its orbit. The rotation being uniform, while the orbital motion, owing to the great eccentricity of the orbit, is affected by a very large inequality, it follows that there is a libration in longitude of nearly 24° on each side of the mean position. Mr Lowell, in 1897, took up the question anew by combining a long series of measured diameters of the planet with drawings of its apparent surface made from time to time. The latter showed long narrow markings, similar in their general character to the supposed channels seen by Schiaparelli upon Mars, and the constancy of these markings was considered to confirm the view of Schiaparelli as to the slow rotation of the planet. The diameter was found to be 0·8″ greater than the value which had before been generally accepted. The most curious result of Mr Lowell's work was that the body of the planet is possibly somewhat ellipsoidal, the longer axis being directed toward the sun. This, however, cannot be regarded as established. It is worthy of remark that the larger diameter and the ellipsoidal form may be connected with a curious discrepancy found in discussing the meridian observations of the planet. This consists in the fact that in the general average, when the planet is east of the sun the right ascension derived from observations seems to be too small, and when west of the sun too great. In either case, it is impossible to observe the real centre of the planet, because the latter always shows a phase like that of the moon, being sometimes a crescent, sometimes a semicircle, and sometimes gibbous, according to the position in the orbit. The observers sometimes directed their view upon the bright limb which, of course, was always towards the sun, and sometimes upon the apparent centre of the illuminated surface; hence reduction from the point observed to the centre of the planet was necessary to derive the position of the centre supposed to be given by the observations. This reduction was necessarily a fraction of the assumed diameter of the planet, which had to be determined from other sources. The discrepancy shows that the reduction actually applied was, in the general average, too small by a considerable fraction of a second, but it is impossible to say with certainty whether this arose from a personal equation of the observers, due to the fact that the limb of the planet nearest the sun was so much brighter than the rest of the disc that the observers of the apparent centre set very nearly on the limb, or from the assumed diameter being too small, as supposed by Mr Lowell.

Venus.

Schiaparelli made his well-known studies upon Venus contemporaneously with those upon Mercury, and his conclusions were summed up in five brief notes read to the Milan Academy during the year 1890. The first four of these are devoted to a very full and exhaustive history of all existing telescopic observations upon the supposed spots of the planet from the time of Bianchini (1728), the result being that no positive conclusions can be drawn from any of the observations, either as to permanent markings on the planet or its time of rotation. Herschel had devoted special attention to the subject, and, as is well known, could find no evidence of any well-defined period of rotation. The first definite clue to a conclusion which Schiaparelli could obtain, was suggested by the long continuance of two faint spots near the southern cusp of the planet. It is true that these spots were not always visible; yet, under the best conditions, they could be seen at some hour every day for weeks at a time, and sometimes during several hours on the same day. He agreed with Herschel and others of the best astronomers in concluding that these spots were not really permanent, but disappeared at the end of a few weeks at most. At the same time the faint temporary spots which he succeeded in discerning remained immovable for several hours in succession, thus precluding the idea of previous observers that the planet rotated in a period not very different from twenty-four hours. Moreover, their continued observation for several weeks seemed to show that their rotation must be very slow, and their period several months, perhaps equal to that of the revolution of the planet round the sun. Lowell reached a similar but more definite conclusion, maintaining that the planet really did always present the same face to the sun. But in the opinion of the most conservative astronomers, the whole subject of the rotation, both of Mercury and Venus, is still in doubt. The supposed spots are so indefinite, that it is not safe to rest a positive conclusion on them. The most recent and most definite result is that of Belopolsky at Pulkowa, who determined by the spectrographic method the difference of the velocities with which various points of the circumference of the disk of Venus were moving to or from us. The mean of a great number of measures gave a velocity of rotation of 0·9 km. per second, corresponding to a period of twelve hours. So short a period seems incompatible with the absence of sensible ellipticity in the figure of the planet, yet the observations greatly weaken Schiaparelli's conclusion (*Ast. Nach.* No. 3641).

Conclusive evidence that Venus is surrounded by a transparent, or at least a translucent atmosphere, was gathered at the transit of Venus in 1882, and scarcely less conclusive was the evidence that this atmosphere bears a great volume of clouds, which probably would completely obscure the surface of the planet. After one-half of the dark body of the planet had entered upon the disc of the sun, that portion of its outline without the sun became visible as a thin line of light extending around its border. This line can be attributed to no other cause than the refraction of the sun's rays produced by an atmosphere surrounding the planet. Had this atmosphere been quite transparent, we should have expected the line of light to make its first appearance at the most distant point A (see Fig. 1) of the circumference of the planet, owing to the fact that before the planet had half entered, the only rays that could be refracted to us would necessarily pass near this region. From this point, A, the line of light should have extended in both directions, until, after more than half the planet was on the solar disc, it would have been seen complete. Instead of this the light first showed itself along a small arc at the point B. A few minutes later, small portions of it began to glimmer here and there around other parts of the dark circumference, but it was not until the planet was almost entirely on the disc that the arc of light became plainly continuous. It is difficult to attribute this phenomenon to any other cause than clouds floating in the lower region of the atmosphere, and possibly an irregularly translucent condition of the latter rather than entire transparency.

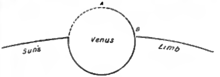


Fig. 1.

There is a class of telescopic observations which, at first sight, seem incompatible with those made about the time of a transit. At intervals of eight years before and after a transit, Venus passes very near the sun. On such an occasion, in 1866, Lyman, at New Haven, saw the entire outline of the planet as an exceedingly fine ring of light, and on 1st and 5th December 1890 Barnard saw the entire outline except about 20°. An atmosphere refracting rays so strongly that the illumination of the entire planet would be visible under such circumstances, ought to show a bright arc of light on the side farthest from the sun, whereas, in fact, this was always the darkest portion of the outline. A very elaborate discussion of all the observations of this class has been made by H. N. Russell (*Astrophysical Journal*, ix. 284), who proposes the explanation that the visible outline which we see is not the illuminated surface of the planet but the upper illuminated region of the atmosphere, bearing suspended particles of dust or fog. He also concludes that the atmosphere of Venus is decidedly rarer than that of the earth. This seems the best explanation of the seeming paradox that has yet been offered.

Mars.

The earlier telescopic observers had no difficulty in discerning bright and obscure regions on the surface of Mars, and in concluding from the varying aspects of these regions that it rotated on its axis in a period of a little more than twenty-four hours. The only important additions to our knowledge of the surface between the time of Herschel and Schroeter, and the opposition of 1877, were embodied in maps of the planet, which agreed in the main features, but differed greatly in details. At the opposition of 1877, the planet was unusually near the earth; and although its south declination was not favourable to observations in the northern hemisphere, Schiaparelli instituted a series of studies which, continued through several subsequent oppositions, have given rise to a large mass of literature on the subject. Observers had long seen, or fancied they could see, a remarkable resemblance between the surface of Mars and that of the earth. The brighter regions were supposed to be continents; the darker ones oceans. Schiaparelli's great discovery was that these supposed oceans were connected by comparatively narrow streaks, to which he applied the term channels (*canale*), a word which, through an unfortunate misconception, has been translated into English as "canal," thus giving rise to the impression that the features in question were the work of the inhabitants of Mars. The studies of these features by other observers have been so numerous that it is impossible even to summarize them. Some have failed to see the channels at all, but the most successful in seeing and drawing them have been the observers at the Lowell Observatory. A careful comparison of the maps of Schiaparelli with each other, and with that of Lowell, shows that there is by no means a complete agreement as to these features. Schiaparelli depicts them as rather obscure and more or less diffused bands or streaks of appreciable breadth, whereas in Lowell's drawings they appear as sharp, fine, dark lines. The channels seen by Lowell are much more numerous than those seen by Schiaparelli, but at the same time we cannot identify all of Schiaparelli's channels on Lowell's map. An additional characteristic of the latter is that the numerous junction points of the channels are frequently marked by round, dark spots, like circular lakes, which do not appear on Schiaparelli's map. The current interpretation of these features has been contested by Barnard, who seems to have seen the planet under much more favourable conditions than either of the two other observers. He had the advantage of the great aperture of the Lick telescope, and the very fine seeing now and then obtained at Mount Hamilton. In exceptionally favourable circumstances he could see markings so minute, intricate, and abundant that it was impossible to delineate them. They were even more numerous on the so-called seas than on the broad continental regions. They were usually more or less irregular, consisting in delicate differences of shade. No straight and sharp lines were seen. Between the black spots which abounded in a certain region were seen diffuse hazy lines, rather irregularly formed (*Monthly Notices R. A. S.* vol. lvi. 1896, p. 166). These discrepancies between the two observers are all the more noteworthy, in view of the skill of each, Schiaparelli being known for his conscientious care in avoiding every sort of illusion, and training his eye to see only what is existent, while Barnard is equally conscientious, and had at his disposition telescopic power far exceeding that of Schiaparelli.

The apparent discrepancy can, we believe, be reconciled by some considerations on the psychology of vision. If we observe a stippled engraving of such an object as the human face from a certain distance, we see nothing but continuous light and shade. If we seek to draw what we see, we may form the best representation by lines representing the outlines of the human features. But if, instead of studying the engraving at a distance, we look at it through a magnifying glass, we see no lines whatever but only collections of points, perhaps without any well-defined arrangement, thicker in some regions than in others, and of various sizes. We thus learn that the eye possesses a property of representing collections and rows of points to the visual sense as continuous lines of light and shade. From this point of view it is quite natural that such features as those described by Barnard should, when seen with less sharpness, present to the eye the appearance shown on the maps of Schiaparelli. The discrepancy between the outlines, as drawn not only by the two observers, but by the same observer at various times, shows that there is something shadowy and indefinite, we may even say doubtful, in the objects depicted. Some of the channels are unmistakable. Of others the difference of shading is so slight that visual distinctness is scarcely possible, and none of them, perhaps, can be considered as anything but the result of a combination of complex features too minute to be separately visible. In this connexion a short paper by Cerulli in the *Astronom. Nach.* (Bd. 146, S. 155) may be read with interest. This observer found that after having observed the channels of Mars for two years through a telescope, he was able, by looking at the moon through an opera-glass, to see similar lines upon its surface, but these seeming lines were shown by observations with the telescope to be unreal, being only the result of the unconscious action of the eye in joining together slight and irregular combinations of light and shade in such a way as to produce regular forms. As this action was the result of a long habit, the fact shows the possibility that long practice in observing may result in an observer seeing objects incorrectly. Could we see Mars with an optical instrument bearing the same ratio to a common telescope that the latter does to an opera-glass, the result might be the same for Mars that Cerulli found for the moon. The doubling of the channels noticed from time to time by some observers must also be placed in the category of doubtful phenomena or probable illusions, and there is on this point an absence of agreement among the observers which must throw doubt on their conclusions. On Schiaparelli's map and in Lowell's drawing the double channels are simply parallel ones of equal strength, so far apart that they are distinctly separate objects, though others find the supposed duplicity very difficult to make out. It is conceivable that an observer, under unfavourable conditions, might find these pairs of markings hard to separate; but, were such the case, they would be seen as a very broad band and not as the narrow streaks commonly depicted.

Atmosphere of Mars.

The well-known fact that the polar regions of Mars are covered with a white deposit during the Martian winter, of which the greater part melts away in the course of the Martian summer, has given rise to the belief that the planet has an atmosphere and oceans like our own. Apparent changes in the visibility of different spots at different times seem to confirm this view, by suggesting that portions of the planet are from time to time rendered invisible by clouds. But the telescopic observations of Lowell, and those made with a spectroscope by Campbell, both tend to weaken this view; Lowell, from his own observations, reached the conclusion that the atmosphere must be much rarer than that of the earth and comparatively cloudless, and Campbell, by comparing the spectra of Mars and the moon, could not certainly discern any well-marked difference between them. It is known that the moon has no atmosphere sufficient to produce an absorption spectrum. Hence Campbell's observations show that if the same thing is not absolutely true of Mars, it must be approximately so, in that no spectral lines are strengthened by the atmosphere to an obvious extent. Just how dense an atmosphere could exist without having any appreciable effect on the lines, especially how much aqueous vapour it might contain, we cannot state with precision, but we seem justified in concluding that the Martian atmosphere is much rarer and much more free from aqueous vapour than that of the earth. The problem of reconciling the supposed winter snow deposits with the great rarity of the atmosphere presents no difficulty. But there is real difficulty in supposing that the summer temperature can be so high as to melt any considerable thickness of snow or ice. The most probable explanation of this phenomenon seems to be that the polar caps are in the nature of hoar frost deposited during the extreme cold that must prevail in a region completely cut off from the rays of the sun, and not warmed as our polar regions are by air currents from the warmer equatorial regions. Ice slowly evaporates at a temperature below the melting-point. It is not, therefore, necessary to suppose that the sun's rays warm the polar regions of Mars even up to the melting-point of water, in order to explain the evaporation of a thin deposit of frost during the Martian summer.

Our general conclusions as to the physical condition of the surface of Mars may be summed up as follows: (1) The dark regions on the planet are not oceans, as was formerly supposed, the more probable hypothesis being that the dark colour is simply that of the solid surface of the planet. The amount of heat received from the sun on each unit of surface is less than half that received by the earth, and it is commonly supposed that the surface of our globe is, in the general average, warmer than it would be if our atmosphere were less dense or less rich in aqueous vapour. It is therefore very unlikely that the surface of Mars can be warm enough to allow of the presence of large bodies of water in the liquid state. (2) The so-called canals or channels are probably not the definite features that appear on the drawings, but rather the result of slight suggestions made to the eye by more or less irregular differences in the minute shadings and colour tints on the surface of the planet.

Satellites of Mars.

Probably no astronomical discovery since that of Neptune has so surprised the astronomical world as the announcement, made in August 1877, that Professor Asaph Hall had discovered two satellites of Mars. The most remarkable feature of these bodies is their minuteness, their estimated diameter being only 8 or 10 miles, and they are the smallest known bodies in our system, except possibly a few of the more recently discovered minor planets. Among satellites the inner one is unique, in that its time of revolution round the planet is less than the Martian day, being in fact less than nine hours. The result is that to an observer on the planet it would rise in the west and set in the east. They are, of course, difficult objects to observe, especially at those oppositions when the planet is farthest from the sun; but at the favourable oppositions, when Mars is near its perihelion, they may easily be seen with a telescope of 12 inches' aperture or upwards, if the observer takes the precaution to cut off the light of Mars from his field of vision. Particulars relating to the elements and motions of these bodies are given on pages 744-5.

Minor planets.

The number of known members of the group of minor planets now approaches 500, and is increasing so rapidly that no trustworthy estimate of its total can yet be made. The mean opposition magnitude of those most recently discovered generally lies between the 11th and 13th, and sometimes is of the 14th or 15th. New discoveries are now made entirely by photography. A sensitized plate is exposed in the focus of an equatorial photographic telescope, moved by clockwork so as to follow the stars in their diurnal motion, and on this when developed the stars appear as minute dark dots. But if the image of a planet is imprinted on the plate, it will appear as a short line, owing to the combined effect of its orbital motion and that of the earth. The ease with which such a plate can be examined under a microscope, renders this method much simpler and more expeditious than the old one of searching for the planet visually. One of the bodies recently added to the list is, in the character of its orbit, quite unique. The orbits of all the minor planets known up to 1898 were situated between those of Mars and Jupiter, but in August of that year, Witt, of Berlin, found a planet which at perihelion comes considerably within the orbit of Mars. The name of Eros has been assigned to it. A remarkable feature is that the two orbits, those of Eros and of Mars, are interlinked in such a way that if both were material they would pass through each other like two links in a chain; but the inclination of the orbits and the large eccentricity of Eros are such that, at present, there is no very near approach of the two orbits, though this could not always have been the case in the past, nor will it be the case in the future. One result of the secular variations must be that the two orbits will, at some period, actually intersect, and near this time Mars and Eros will approach so close to one another that the orbit of the latter may be completely changed. Not unlikely this was the case at some unknown epoch in the past, previous to which the orbit of Eros may have been very different from what it is now. Approximate elements of this body referred to the equinox of 1900 are these:—

Epoch, 1898, *August* 31, 5 *G.M.T.*

Mean long. at epoch	342° 48′
,, anom. ,, ...	221° 37′
Long. of perihelion	121° 11′
,, node	303° 31′
Inclination	10° 50′
Angle of eccentricity	12° 52′
Daily mean motion	2015·2326″
Log. mean distance	0·163798″
Eccentricity	0·22275″

From the mean distance and eccentricity it follows that the least distance[1] of the planet from the sun is 1·1333; the greatest, 1·7829. At the descending node on the ecliptic its distance from the earth's orbit is only 0·149, a distance much less than that of any other known planet. The earth passes this point about 24th January of each year; but it is only on rare occasions that the planet will be very near the corresponding part of its orbit at this date. A tantalizing fact for the astronomer is that such a passage occurred about 24th January 1894, before the planet was recognized, and that so near an approach will not occur again until 1975. Oppositions not much less favourable than that of 1894 will occur in 1931 and 1938. The epochs of these nearest approaches can be utilized for more exact measures of the solar parallax than have yet been made. Seven years before and after each most favourable opposition another occurs at which, though less favourable, the planet comes so near as to offer an excellent opportunity for the measures in question.

Distribution of mean motions.

A study of the distribution of the mean motions of these bodies shows a singular feature, apparently connected with their origin, on which it may throw some light. About 1870 it was noticed by Kirkwood that when these mean motions are arranged in the order of their magnitude, gaps are found in the series corresponding to the points of commensurability with the mean motion of Jupiter; that is to say, the period of Jupiter being in round numbers twelve years, there are few or none of these bodies which have periods of one-half, one-third, or two-fifths of twelve years. If there were any of the group having any of these periods, it is known that the

Distribution of 400 Minor Planets into Groups, according to Mean Motions and Mean Distances.

Limits of Mean Motion.	Limits of Mean Distance.	Breadth of Zone.	No. of Planets.	Commens. with Jupiter.
Exceed 1000	Below 2·33	...	31	
910 to 1000	2·33 to 2·48	·15	64	
870 ,, 910	2·48 ,, 2·55	·07	6	3:1
790 ,, 870	2·55 ,, 2·72	·17	79	
760 ,, 790	2·72 ,, 2·79	·07	65	
750 ,, 760	2·79 ,, 2·82	·03	9	
740 ,, 750	2·82 ,, 2·84	·02	1	5:2
710 ,, 740	2·84 ,, 2·92	·08	29	
690 ,, 710	2·92 ,, 2·98	·06	5	7:3
610 ,, 690	2·98 ,, 3·24	·26	96	
580 ,, 610	3·24 ,, 3·34	·10	0	2:1
540 ,, 580	3·34 ,, 3·52	·18	10	
460 ,, 540	3·52 ,, 3·88	·36	0	5:3
400 ,, 460	3·88 ,, 4·28	·40	5	

---

[1] Distances among the planets are expressed in radii of the earth's orbit.

perturbations produced by Jupiter would be greatly exaggerated in the course of centuries. It was therefore supposed that if there ever had been planets with these mean motions, their orbits would have been unstable and subjected to large and unknown changes. This conclusion, however, is misleading. The result in question follows when the integration of the equations of motion of the planet is only approximate, but a rigorous integration shows that commensurability of the kind in question does not lead to any instability. When Kirkwood made his investigation, only about 100 of these bodies were known, but a study of the 400 members of the group whose mean motions are fairly well determined shows the matter in another and more striking light. In the preceding table is shown the distribution of those members in zones of mean motion and mean distance.

A study of this table shows that what we see in the group are not gaps in an otherwise uniform series, but a tendency to cluster into zones, which are condensed near the middle of the regions between the lines of commensurability and thin out gradually towards those lines. For the most part there is no absolute dividing line between the zones, the number being merely less near the line of commensurability. This, however, is not the case with the two outer zones. In the region 3·24 to 3·34 no planets are yet known, while in the next zone, 0·18 in breadth, there are ten. Then follows a zone 0·36 in breadth, without any, outside of which there are five. That there is a causal connexion between this system of grouping and the lines of commensurability with Jupiter can scarcely be doubted, but, as already remarked, we cannot attribute the paucity of planets approaching to commensurability to any want of stability in their motion. One cannot but suspect that the phenomenon has a cosmogonical origin, and arose from the formation of zones of different degrees of density in the original revolving nebulous mass from which these bodies were formed.

The laws of secular variation of elements show that there is a certain mean plane around which the nodes of these bodies tend to be uniformly scattered, and a certain mean longitude towards which the perihelia tend (*Astronom. Nach.* lviii. S. 210). The position of the mean plane is: longitude of node, 91°; inclination to ecliptic, 1° 3′. The eccentricity and perihelion of the mean orbit are: eccentricity, 0·0321; longitude of perihelion, 3°. This last result does not imply that we have here the mean of all the eccentricities, but that the mean value of the $e \sin \varpi$ and $e \cos \varpi$ for all the orbits will be very near the products of the eccentricity just given into the sine and cosine of 3°. The result may be otherwise expressed by saying that the action of each planet tends to bring the mean plane of the orbits of the small planets into its own plane, and to elongate the orbits in the direction of its own aphelion. As Jupiter exerts the most powerful action on the minor planets, a tendency thus arises among the latter to coincidence of their nodes and perihelia with the node and perihelion of Jupiter.

Jovian system.

The most notable addition to our recent knowledge of the Jovian system consists in the discovery of a minute additional satellite by Barnard in September 1892, with the 36-inch telescope of the Lick Observatory. It is much nearer the planet than the four previously known, and the only designation which it has thus far received is that of "fifth satellite," the order of distances of the satellites thus being the fifth, first, second, &c. As regards visibility it is one of the most difficult objects—perhaps the most difficult—in the solar system, and has been seen only with a few of the largest telescopes. Its mean synodic period of revolution is 11 h. 51 m. 27·635 s. It has been assiduously observed by its original discoverer, who finds a quite appreciable eccentricity in its orbit. From his observations, combined with a consideration of the theoretical effect of the ellipticity of Jupiter, its pericentre is found to revolve with a more rapid motion than that of any other known celestial body, making more than an entire revolution in a year. The four satellites formerly known have been found by Barnard and W. H. Pickering to exhibit singular anomalies of apparent form while in transit across the disc of Jupiter. The first sometimes appeared double on such occasions, although no such form had been seen at other times, and it became a question whether it could really consist of two bodies. After a careful study of the subject, Barnard reached the conclusion that the appearance was due to a bright band around the equatorial region of the satellite, while the poles were of a darker tint, the varied shading of the belts of Jupiter on which it was seen projected during the transit resulting sometimes in only the polar regions being visible. Anomalies of form noticed in the other satellites have not been confirmed by the observations of Barnard (*Monthly Notices R. A. S.* liv. 1894, p. 134).

The ease with which the complex cloud-forms on Jupiter can be observed has led to a careful study of its surface by many observers. The British Astronomical Association has a special section devoted to this study. Although a great mass of observations has thus been collected, illustrative of the changes continually going on at the surface of the planet, it cannot be said that any radically new views respecting its constitution have been gained, nor that the observations have yet led to any researches that would throw much additional light on the subject. The most noteworthy phenomenon of late years has been the garnet spot which appeared in middle southern latitude in 1878. For ten years no great changes were noticed in it; then it gradually began to fade away. About 1892 it brightened up again, then again began to fade, and has been seen only occasionally and with difficulty since 1897. The most careful investigation of its motion has been made by Lohse, whose work embraced the entire period of visibility from 1878 to 1897. His most remarkable conclusion is that the period of revolution of the spot has been undergoing a fairly continuous change. For several years before and after 1891, it was 9 h. 55 m. 41 s. But if with this motion its position is computed back during previous years, it will be found to have wandered over more than two-thirds the circumference of the parallel on which it is situated. This result emphasizes the fact already known, that if Jupiter has any solid nucleus it is invisible to us; for had the spot in question been connected with such a nucleus, had it even been in the nature of an eruption from a volcano, its period of revolution would necessarily have been uniform. Granting—as seems to be unavoidable—that the visible surface of the planet is either liquid or gaseous, the persistence of the spot through twenty years is remarkable. The most plausible hypothesis is that it is in the nature of an island floating upon a liquid surface, but it does not seem at all probable that any formation floating in an atmosphere could have lasted through such an interval. Still, it is an open question whether the so-called belts of Jupiter indicate a liquid or gaseous condition of the visible surface. The great difficulty in the way of the liquid hypothesis is the very great difference in the times of rotation of the equatorial portions of the planet and the spots in middle latitudes. It is now found that while the latter, like the red spot, rotate in 9 h. 55 m. and a somewhat variable number of seconds, the equatorial markings make a revolution in about five minutes less time, or 9 h. 50 m. *plus* a varying number of seconds. In this respect Jupiter resembles the sun, whose rotation follows the same law. In the case of the planet, however, it is very remarkable that no intermediate times of rotation seem to have been well made out. Whether this arises from the fact that observers have not devoted to this subject the attention which it deserves, or whether the line between the two times of rotations is a narrow one, is a question which cannot yet be decisively answered. The important point is that the difference between the two times corresponds to a difference of about 7·5° in the motion round the planet during a terrestrial day. This corresponds to a linear motion on the surface of the planet of more than 30,000 miles per day, a motion which it seems difficult to reconcile with liquidity of the visible surface.

The view expressed in the ninth edition of this work, that Jupiter shines partly by its own light, has not been confirmed by later researches. The complete disappearance of the satellites, even in the most powerful telescopes, while in the shadow of Jupiter, shows that they cannot receive sufficient light from that planet to be visible, and the uniform darkness of the shadow of the satellite when seen on the planet, shows that the latter cannot be self-luminous. It is also to be remarked that, were it only moderately self-luminous, the colour of the light which it sends to us would be red, such light being that first emitted from a heated body when its temperature is raised. While it is quite possible that a small quantity of such light may reach us from the planet, no facts to prove it have yet been adduced.

Saturnian system.

In April 1898, the probable discovery of a ninth satellite of Saturn by W. H. Pickering was announced from the Harvard College Observatory. The new object was detected by means of four photographs of the region in the immediate neighbourhood of Saturn, taken on 16th, 17th, and 18th August 1898. A minute star was found on each of the plates, occupying a position which was vacant on the other plates. The object was of the fifteenth magnitude, and therefore so faint as to be invisible to the eye by any but the most powerful telescopes. Its position relative to Saturn could not be readily determined, because the long exposure necessary to bring out so faint an object resulted in the image of Saturn being completely "burned" out on the plates; in fact, the planet and rings appeared only as a large, dark, faintly-defined blotch of light, several times larger than the planet itself. Assuming that the object in question was a satellite of Saturn, it must be at some distance outside of all the other satellites, and its time of revolution must be several months. As the object does not seem to have been certainly detected at the following opposition, some doubt may yet exist as to its nature. The planet is now in a region rich in stars, and as so faint an object is easily lost among the hundreds which surround it, its detection is difficult.

The visible surface of Saturn bears a certain resemblance to that of Jupiter, but the markings are so much fainter that it is difficult, if not impossible, to locate and identify them with precision. There have been two notable exceptions to this rule. Sir William Herschel once saw a spot which lasted several weeks and enabled him to fix the time of rotation of the planet on its axis at 10 h. 16 m. The second case occurred in 1876. On 7th December of that year a bright white spot suddenly appeared in the equatorial region. It continued more than a month, gradually extending its dimensions in an east and west direction, so as to assume the form of a long streak, and at the same time growing fainter. From observations of the brighter portion, Professor A. Hall fixed the time of rotation at 10 h. 14 m. The question whether any markings ordinarily exist on the planet strong enough to be certainly located is an open one among the best observers. Cautious students of the subject will probably give most weight to the negative side. (See *Monthly Notices R. A. S.*, for observations and discussions, by Williams and Barnard.)

Saturn's rings.

The most noteworthy addition to our knowledge of the rings of Saturn has been made by Keeler. That these appendages cannot be rings of continuous matter, either solid or liquid, has long been well established by theory, which showed that the equilibrium of such an object would necessarily be unstable. The alternative hypothesis that the rings are a cloud of minute satellites, or perhaps mere particles, too small to be individually visible, but so numerous as to look in our telescope like a continuous mass, was exhaustively investigated by J. Clerk Maxwell in his Adams prize essay published about 1860; but no direct evidence bearing on the question was obtainable until the spectroscope was brought into requisition. By the aid of this instrument in its present refined form, the motion of a body to or from the earth can be made evident by the change produced by the motion in the wave length of the spectral rays. The method is equally applicable whether the body is self-luminous or shines by the reflected light of the sun. By photographing the spectrum of Saturn and its rings when the image was thrown upon the narrow slit of a spectrograph, Keeler found that the lines across the spectrum were bent and broken in such a way as to show that the inner part of the rings revolved with greater velocity than the outer part, the motion of each part being that which would correspond to the motion of a satellite revolving at the same distance. The extreme thinness of the rings was demonstrated in a more striking manner than ever before by Barnard and others in 1892, during one of those rare times at which the plane of the ring passes between the earth and the sun. In such a case the sun shines on one surface of the ring, while only the opposite surface is turned towards us. Considering it as a cloud of satellites, each of the latter should in such a case be fully illuminated by the sun, except so far as it might be in the shadow of those outside of it. The outer satellites of all would necessarily be fully illuminated and also be visible to us if we had sufficient telescopic power, because there would be nothing to hide their light. Now, it is a singular fact that, in these circumstances, the ring was completely invisible, even with the 36-inch telescope of the Lick Observatory. This shows that the entire ring must be so thin that its edge is completely invisible, even in the full light of the sun, at the distance which separates us from the planet. On the other hand, the objects composing it must be completely opaque, as is shown not only by their disappearance in the circumstances we have mentioned, but by the darkness of the shadow which they cast upon the planet when the sun illuminates them obliquely. The cloud of satellites is so dense that a ray of light cannot penetrate the mass.

An interesting question still open is the nature of the so-called divisions of the rings. Are these divisions real or are they simply apparent, arising from a darker colour in the matter which composes them? In the case of the sharpest and best-known division, to which the name of Cassini has been given from its first observer, there would seem to be little doubt that the division is real. But there is some doubt in the case of the other divisions. It is now well established that the dusky or crape ring, which is on the inside of the brighter one, is really in the nature of an inner border of the bright ring, the one shading off imperceptibly into the other. While many excellent observers have sometimes thought they saw a complete separation between the bright and the crape rings, no such phenomenon has been seen in the great telescopes of our times, and it is almost certain that the dark colour of the crape ring arises merely from its tenuity and transparency. From Barnard's observation of the passage of Japetus through the shadow of Saturn and its rings it appears that the transparency gradually diminishes from the centre of this ring to its line of junction with the bright ring. If there should ever be a transit of Saturn centrally past a bright star, many questions as to the constitution of the rings might be settled by noting the times at which the star was seen through the divisions of the ring.

Uranian and Neptunian systems.

The great distance of Uranus and Neptune, and the faintness of their illumination by the sun, have as yet prevented our reaching any well-defined views as to their physical constitution. Micrometric measures seem to show that the globe of Uranus is slightly elliptical, like that of the other outer planets; this would indicate that the planet has a somewhat rapid rotation. In the case of Neptune, although no well-marked ellipticity has been observed, it has been established in a satisfactory though intricate way. The plane of the orbit of the satellite is found to be in continuous motion, and the only cause to which this can be attributed is the ellipticity of the planet itself. The result of this cause would be that the axis of the orbital plane would perform a slow revolution around the axis of the planet. The observed motion is undoubtedly a revolution of this kind, but up to the present time the arc described has been so small that neither its radius nor its period can be determined.

Spectra of the planets.

Were the planets surrounded by comparatively dense atmospheres, especially atmospheres markedly different from that of the earth, that fact would be most easily made known by the spectroscope, since unknown substances in such an atmosphere would show absorption lines differing from those of the solar spectrum. A very dense atmosphere of the same general character as that of the earth would be indicated by a strengthening of the telluric lines. We remark in this connexion that the lines observed in the solar spectrum are of two classes—those which arise from the absorption of the gases surrounding the sun and those produced by our own atmosphere. The latter seem to be principally due to the aqueous vapour in the air. As the light which reaches us from a planet necessarily comes from the sun and passes through our atmosphere, we must expect to see all the lines of the solar spectrum in the spectrum of any planet, and the important question is whether any new lines or any changes in the strength of the known ones are also found. Studies with this end in view have been made by Huggins and Vogel. In the case of the planets Mercury, Venus, Mars, and Jupiter, the evidence of any well-marked modification of the solar spectrum does not seem conclusive. If, as appears from what has just been said, the inferior and denser regions of the atmospheres of these bodies are mostly filled with clouds and vapour, we should not expect to gain much evidence in this way. In the case of Mars and Jupiter, Vogel thought he detected an increased absorption in the red region. The general conclusion from the studies of these two investigators seems to be that, at least in the case of the three inner planets, there is no evidence of an atmosphere differing materially from that of the earth. In the spectrum of Jupiter, however, a line was found in the red of wave length 6178 which does not belong either to the sun's or the earth's atmosphere. Vogel remarks that it may be doubtful whether this line arises from some new and unknown substance in the atmosphere of Jupiter or simply from some combination with which we are not familiar. The case with Uranus and Neptune is different. The extreme faintness of the light from these planets renders it difficult to distinguish the Fraunhofer lines in their spectra, but a number of dark bands were found by Huggins, Keeler, and Vogel in the easily visible portion of the spectrum of Uranus. The following is a list of the bands on which the observers are substantially in agreement:—

Wave Length.	
618.	A broad band fading off towards the red.
596.	A narrow faint band.
575.	Darkest part of a broad band, extending from 578 to 565.
543.	Middle of the darkest band.
486.	A group of fine lines.

Vogel found a few faint bands above 486, and by photographing the spectrum from F into the ultra-violet Huggins was able to distinguish the stronger Fraunhofer lines. The spectrum of Neptune seems to be of the same general character as that of Uranus; but the bands are more difficult to see, owing to the extreme faintness of the light. The inference to be drawn from these studies is that these two planets are surrounded by very deep, dense atmospheres, probably materially different in constitution from our own; but until we learn what combinations of known substances, if any, might be adequate to produce such bands as those just described, it is impossible to reach any conclusion as to the nature of those atmospheres.

Photometry of solar system.

While the photometry of the fixed stars has, in recent years, been placed on a definite scientific basis, the same can scarcely be said of that of the bodies of the solar system. This is owing largely to the difficulty, if not the impossibility, of establishing general laws as to the proportion of light reflected from bodies at various angles of incidence and reflection. We must, therefore, confine ourselves to a statement of the apparent magnitude of the principal bodies of the solar system under mean conditions. A fundamental datum of the subject is an expression for the quantity of light received from the sun as compared with that from a fixed star of given magnitude, a result which is best expressed in the form of a stellar magnitude of the sun. The results of attempts to fix this datum are so discordant that entire confidence cannot be felt in any of them. To express it as a stellar magnitude of the sun we remark that, on the photometric scale now adopted, an increase of a hundredfold in the quantity of light corresponds to a *drop* of 5 units of stellar magnitude in the body emitting the light. In general, a change of *n* stellar magnitudes is equivalent to a multiplication or division of the amount of light by $10^{0\cdot 4n}$, a number whose common logarithm is $0\cdot 4n$. The best results for the stellar magnitude of the sun as thus defined seem to be − 26·6 (Wollaston), − 25·8 (Bond), and − 26·6 (Zollner). Giving Zöllner's result double weight, we have the stellar magnitude of sun = − 26·4.

The two best determinations of the ratio of sunlight to that of the full moon seem to be those of Bond and Zollner, which are 470980 and 619000 respectively. Müller (*Photometrie der Gestirne*) estimates the best mean result to be 569500.

For the stellar magnitudes of the planets and satellites, we have room only to state what seem to be the best mean results. In the case of Mercury and Venus, the variations are so great that definite results cannot be given.

		Mag.
Mars: at mean opposition; =		−1·75
Jupiter " " =		−2·23
Saturn without rings		0·88
Uranus: at mean opposition		5·75
Neptune " "		7·84
Satellites of Mars:	Phobos	12·8
" "	Deimos	13·1
Satellites of Jupiter:	First	6·0
" "	Second	6·1
" "	Third	5·6
" "	Fourth	6·6
Satellites of Saturn:	Mimas	11·19
" "	Enceladus	11·4
" "	Tethys	10·5
" "	Dione	10·6
" "	Rhea	9·9
" "	Titan	8·5
" "	Hyperion	12·8
" "	Japetus— from	10·44
	to	11·80
Satellites of Uranus:	Titania	14·2
" "	Oberon	14·5
Satellite of Neptune		13·3

Comets.

For details respecting the new comets, especially periodic ones, which have been discovered since 1880, reference may be made to the article on that subject; what we are here concerned with is the general question of the origin and constitution of these bodies. A striking confirmation of the view that the comets of short period from time to time become members of our system through the action of one of the larger planets, nearly always Jupiter, is afforded by the case of Comet V. of 1889, discovered by Brooks on 6th July of that year. It was soon found to be moving in an orbit with a period of about eight years, and when its motions were traced back it was ascertained to have passed very near the planet Jupiter in June and July 1886. Attempts to compute its orbit previous to this approach were made by Chandler and Poor. The former, from a preliminary investigation, reached the conclusion that the comet was probably identical with that of Lexell, which had been thrown into some new and unknown orbit by the action of Jupiter more than a century ago. Poor's inquiry, however, which was made on more complete data, seemed to show that this view is untenable and that the comet had never before been seen. As to the origin of comets, the most important development has been the establishment of the general fact that they belong to the solar system, and are not stray wanderers through space, as was formerly thought possible. Were the latter the case, they would not partake of the motion of the solar system through space. Consequently, as the sun pursued its journey more comets would be found coming from the direction of its motion than from the opposite direction. Those which did come from the former direction would in general move in decidedly hyperbolic orbits. Now we may regard it as established that no comet moves in such an orbit. It is true that some of the computed orbits have a hyperbolic character, this being shown by the eccentricity coming out slightly greater than unity; but the excess, even in these exceptional cases, is always so small that we can only regard it as the result of accidental errors of observation on such ill-defined bodies. The fact being accepted that these bodies, before their observed entry into our system, were accompanying the sun on its journey through space, we are led to the following very probable conclusions:—All comets are to be regarded as having been in the beginning outlying nebulous masses, belonging to the same mass of matter as that which formed the solar system, and moving with it, but mostly at such great distances from the sun that their periods of revolution would be measured by tens or even hundreds of thousands of years. Were it not for the effect of planetary attraction long periods like these would be the general rule, though not necessarily universal. But at every return to perihelion a comet will be to some extent either accelerated or retarded in its movements by the action of Jupiter or any other planet in the neighbourhood of which it may pass. Commonly the action will be so slight as to have little influence on the orbit and the time of revolution. But should the comet chance to pass the orbit of Jupiter just in front of the planet, its motion would be retarded and the orbit would be changed into one of shorter period. Should it pass behind the planet, its motion would be accelerated and its period lengthened. In such cases the orbit might be changed to a hyperbola, and then the comet would never return. It follows that there is a tendency towards a gradual but constant diminution in the total number of comets. If we call Δ the amount by which the eccentricity of a cometary orbit is less than unity, Δ will be an extremely minute fraction in the case of the original orbits. If we call $\pm\,\delta e$ the change which the eccentricity $1-\Delta$ undergoes by the action of the planets during the passage of the comet through our system, it will leave that system with the eccentricity $1-\Delta\pm\,\delta e$. The possibilities are even whether δe shall be positive or negative. If negative, the eccentricity will be diminished and the period shortened. If positive, the minuteness of Δ may result in the eccentricity $1-\Delta+\delta e$ being greater than unity, and then the comet will become for ever a wanderer through the stellar spaces.

Another discovery is that of the possibility of groups of comets moving in nearly the same orbit. It was formerly thought that only by a very improbable chance would two of these bodies be found describing the same orbit at a long interval of time, and, if an instance was noticed in which such appeared to be the case, it was supposed that what was observed on the second occasion was a return of the former comet. In February 1880 a brilliant comet which was suddenly observed in the southern hemisphere was found to be moving in an orbit so nearly identical with that of the great comet of 1843 that no doubt of a relationship could be felt. Yet so slight could have been the deviation from a parabolic orbit in either case that the hypothesis of identity of the two bodies did not seem tenable. The question of possible identity was set at rest by the appearance of a third comet in the autumn of 1882 again describing nearly the same orbit. It now seems likely that these three bodies were parts of one original nebulous mass, situated far beyond the confines of our system, which gradually separated from each other in the course of successive revolutions round the sun.

The question whether the motions of Encke's comet are affected by a resisting medium is not yet conclusively settled. The careful and exhaustive researches of von Asten and Backlund seem to show that resistance is met with during some revolutions and not during others. This would scarcely be the case with a resisting medium, as this agency would always be present if it existed at all. Quite possibly the effect may be due to imperfections in the computation of the perturbations.

Zodiacal light.

There is perhaps no celestial object on which observations are so much wanted as on the zodiacal light. Up to the present time the conclusions which can be definitely stated are somewhat general in their nature. The sun is surrounded by an exceedingly rare cloud of matter of very indefinite outline, lenticular in form, extending out somewhat beyond the orbit of the earth. This matter shines only by reflected sunlight, a conclusion which, probable enough in itself, is strengthened by the spectroscopic studies of A. W. Wright, who found the spectrum to be continuous. In northern latitudes, this object can best be seen in the evenings of February and March and in the mornings of September and October. Observations made in the evening seem to show that the central axis of the apparent light is one or two degrees north of the plane of the ecliptic, and this would point to a slight inclination of the median plane of the whole mass to that of the ecliptic. But it is impossible to reach any definite conclusion as to the position of that plane until the apparent axis of the light among the stars has been carefully delineated night after night through an entire year by an observer in a very clear atmosphere within the tropics. It needs only a glance at the figure of the apparent light in the neighbourhood of the horizon when it can first be seen, about the close of twilight, to show that its breadth at the horizon is very considerable, probably 40 degrees. Continuing the outline around the sun it seems probable that its visible border is nowhere less than 25 or 30 degrees from the sun. It follows that an observer stationed at a high elevation, in a very clear atmosphere, in such a position that the sun should be about 20 degrees below his horizon at midnight, should see this portion of the light as a faint glow in the northern horizon.

The existence of the mysterious counter glow, or *Gegenschein*, as it is commonly called, is now fully established. It is a patch of light in the ecliptic opposite the sun, so faint and indistinct in outline that it can be seen only under the most favourable conditions, including absence of moonlight and a considerable elevation above the horizon. It is invisible when projected on the Milky Way. Barnard has observed it to be larger and more diffused in the autumn than in the spring. No well-marked deviation from the ecliptic or from the point directly opposite the sun in longitude has been detected. The phenomenon has sometimes been supposed to be associated with the zodiacal light, which, on rare occasions and under the most favourable conditions, some observers have thought could be traced near midnight all the way across the heavens, forming a complete arch from east to west. In that case the *Gegenschein* would be a small patch in this zodiacal arch, slightly brighter than elsewhere. Of the various explanations which have been propounded no one can be considered as sufficiently probable to merit acceptance. An ingenious suggestion, and one which it is equally difficult to prove or disprove, is that it is composed of nebulous matter thrown off from the earth, forming a tail to the latter like that of a comet. The quantity of such matter necessary to produce the phenomenon would be minute in the last degree. Similar appendages, if carried by the planets, would be entirely invisible to us, and that of our earth would be visible only because we see through it endways and on a dark sky.

Planetary atmospheres.

Intimately associated with this subject is the question of the conditions necessary to the permanence of an atmosphere round a planet. Dr Johnstone Stoney has recently investigated these conditions, taking as the basis of his work the kinetic theory of gases (*Trans. Roy. Dubl. Soc.* vi. p. 305). On this theory every molecule of a gaseous mass is completely disconnected from every other and is in rapid motion, its velocity, which may amount to one or more thousand feet per second, depending on the temperature and on the atomic weight of the gas. At any temperature the velocities of individual molecules may now and then increase without any well-defined limit. If at the boundary of an atmosphere the velocity should exceed a certain limit fixed by the mass and force of gravity of the planet, molecules might fly away through space as independent bodies. The absence of hydrogen from the atmosphere of the earth, and of an atmosphere from the moon, may be thus explained. If the fundamental hypotheses of Dr Stoney's investigations are correct and complete, it would follow that neither the satellites and minor planets of the solar system nor Mercury can have any atmosphere. If the separate molecules thus flying away moved according to the laws which would govern an ordinary body, they would, after leaving their respective planets, move round the sun in independent orbits. The possibility is thus suggested that the matter producing the zodiacal light may be an agglomeration of gaseous molecules moving round the sun; but several questions respecting the intimate constitution of matter will have to be settled before any definite conclusions on this point can be reached. It is not to be assumed that a molecule would move through the ether without resistance as the minutest known body does, and there is probably a radical difference between the minutest particle of meteoric matter and the molecule of a gas. The relations of identity or difference between such finely-divided matter as smoke and atmospheric haze and a true gas have yet to be fully established, and until this is done a definite and satisfactory theory of the subject does not seem possible.

II. GRAVITATIONAL AND THEORETICAL ASTRONOMY.

The fundamental hypothesis of modern theoretical astronomy is that the motion of each heavenly body is determined entirely by the gravitation of other bodies. Assuming such to be the case, it will be possible to predict the celestial motions with entire precision, if certain fundamental data are given. Such data would be the mass of each body, and its position, velocity, and direction of motion at some given instant. The problem would then be the construction of general formulæ by which the position of each body at any moment whatever could be expressed in terms of the time. In practice we do not use as fundamental data positions and velocities, but the elements of the orbits, including mean distance, eccentricities, position of orbit in space, mean position of the planet at a given moment, and other quantities which do not vary with the time. When the differential equations expressing in a general way the effects of gravitation are integrated, the elements appear in the solution as arbitrary constants, to which values may be assigned at pleasure. The astronomer has then to assign such values that the observed positions of the bodies, whether planets or satellites, shall be accurately represented by the formulæ. The mathematical processes by which the equations are integrated, values assigned to the elements, and the results compared with observation, are perhaps the most difficult and most complicated with which the mathematical astronomer has to deal, and only in comparatively simple cases can he be sure that the minute deviations of the actual movement of a body from his predictions do not arise either from errors in his process or from errors of observation. The equations of motion can be integrated only in the form of an infinite series of complex terms of which all below a certain magnitude have to be dropped, and the difficulty is to be sure that no terms are omitted which could have a sensible value. Generally, it is possible to secure the necessary precision, but in some cases the question whether every possible term which could affect the result has been included may be an open one. One of the most interesting problems of the astronomer at present is whether the motions of the heavenly bodies, as determined by our most refined methods of observation, go on in rigorous accordance with the law of gravitation. This question cannot be settled by a mere comparison of the predicted motion with observations. When differences are found, the question will arise whether they may not be due to errors either in the fundamental elements or in the theoretical computations; in several instances supposed deviations have been found due to the latter cause. One notable case in history is that of the motion of the moon's perigee. This motion was found to be twice as great as was at first supposed to be due to the Newtonian theory, but Clairaut showed that when more rigorous methods were adopted the observed motion was represented. The general rule has been that, whenever an observed deviation has been well made out, it has been traced to the omission of some term of the algebraic formulæ expressing the motion of a planet. To this rule there are two notable exceptions :—

Apparent deviations from the law of gravitation.

Motions of the planetary perihelia.

(*a*) In 1845 Leverrier found that the centennial motion of the perihelion of Mercury derived from observation was greater by 35″ than it should be from the gravitation of the other planets, and his result has been more than confirmed by subsequent investigations, the most recent discussion of observations showing the excess of motion to be 43″ per century. In this case there can be no question as to the correctness of the theoretical result, since the computation of the secular motion of the perihelion is a comparatively simple process. It follows that either Mercury must be acted upon by some unknown body or the theory of gravitation needs modification. The most natural explanation, and that offered by Leverrier, attributes the discrepancy to the action of a group of intra-Mercurial planets. For some time, therefore, careful search was made for these planets. One or more has been thought from time to time to be detected, but every observation of the kind has been disproved by critical examination. The simplest and surest method of discovery is afforded by the consideration that these bodies, if they exist, must from time to time pass between us and the sun, and therefore be visible as minute points on the disc of that body. But nothing of the sort has been brought to light by the photographs of the sun which have been constantly taken in recent years, nor by the observers who, during the last half century, have so assiduously watched the sun for spots. There is another difficulty in the way of accepting this explanation. A mass of bodies sufficiently large to produce the observed motion of the perihelion of Mercury would affect both the other elements of Mercury's orbit and the motions of Venus, but it is shown by the most refined discussions of the observations that these effects are not produced. The most recent surmise on the subject is that the law of gravitation may not act exactly according to the inverse square. A very simple hypothesis propounded by Professor Asaph Hall is that in the expression for the mutual gravitation of two bodies of masses m and m', which, according to the Newtonian law is of the form $\frac{m\,m'}{r^2}$, the exponent 2 should be increased by a very minute fraction. The value of the exponent which would produce the observed effect is 2.000 000 1612, so that the discrepancy is removed if we suppose the attraction to be of the form $\frac{m\,m'}{r^{2.000\,000\,1612}}$. The effect of this modification would be insensible except in the motion of the pericentres of the heavenly bodies. The only cases in which it could be made evident by the century and a half of observations yet made are those of Mercury, the moon, and Mars. The perihelion of Mars does actually seem to be affected by the corresponding increase, which is about 5″·45 per century; but this excess, though made very probable by the observations, is too minute to be conclusively established. In the case of the moon's perigee the increase of motion would be 150″ per century, a quantity too large to escape observation; but unfortunately the theoretical determination of this motion has not yet been made with such precision that it may not be affected by an error of this amount. The most refined determination is that recently made by Professor E. W. Brown, which does show a discrepancy of nearly the required amount; but the difficulties of the determination are such that a conclusive result has yet to be reached.

We may sum up our conclusions on this point by saying that the discrepancy in the case of the perihelion of Mercury is well established, and that there is some reason to believe it a general rule that the motions of the pericentres of the moon and planets are somewhat greater than the gravitation of other bodies is competent to produce. Furthermore, it may be said that the simplest way of explaining the excess of motion is to assume that gravitation increases at a minutely greater rate than the inverse square. Many other modifications of the Newtonian law have been suggested, especially some of a form analogous to that of electro-magnetic action, but none of these consistently represent all the phenomena.

The moon's mean motion.

(*b*) The other exception to which we allude occurs in the apparent mean motion of the moon around the earth, which has now been observed with an approach to modern precision since the year 1675, and with less than modern precision from 1625 to 1675. We have also eclipses of the sun and moon recorded by Ptolemy in the *Almagest*, or observed by the mediæval astronomers, by which the mean longitude of the moon may be followed for more than 2500 years. No amount of research has yet reconciled the results of these observations with gravitational theory. To make clear the existing state of the question, we remark that the inequalities in the motion of the moon are of two classes—those produced by the action of the sun, which are always of comparatively short period, and those produced by the action of the planets, which in exceptional cases are of long period. If, in a period of twenty, thirty, or fifty years, the moon is found to be, in the general average, ahead of her computed place, or behind it, we may say with certainty that the deviation is not due to the action of the sun, because all the effects of this action would be compensated within eighteen years. It has been known for a century that deviations of this character, which are called deviations of long period, really exist in the motion of our satellite. In the middle of the 19th century Hansen announced that he had discovered two inequalities produced by the action of Venus, which completely reconciled these deviations. The theoretical computation of one of these inequalities has been repeated by several investigators since Hansen, and his result confirmed; but it has been shown that the other inequality has no existence in theory, and that it was the result of imperfections in the method employed by its discoverer. If any doubt could arise as to this conclusion, it is set at rest by the discovery that Hansen was in error in supposing that his two inequalities, singly or combined, would represent the observed deviations. Since 1870 the action of the planets on the moon has been exhaustively treated by several investigators with the special object of deciding whether their gravitation could produce any inequality of long period other than that of Hansen, but without result. The impossibility of any such inequality seems to be as well established as any proposition can be that relates to so complicated a subject. Another possible cause of apparent inequalities is to be examined, namely, variations in the earth's axial rotation. What we actually observe is not the absolute motion of the moon, but the relation of this motion to the rotation of the earth on its axis, on which we necessarily depend for our measure of time. Let us now suppose this time of rotation to be increased by a very minute amount. Then the day will be longer by this amount. The motion of the moon in one day will then seem to be greater than it was, though in fact there has been no real change in it. If the rate of rotation is accelerated the opposite effect is produced, the day is shorter, the moon does not move so far in a day, and so seems to be retarded. The discrepancies in question can be explained by variations always less than a second in a year, which, however, accumulate year after year, so that before the end of half a century they might amount to twenty or thirty seconds of time.

Test by transits of Mercury.

A decision between these two causes can be reached only by observations on other bodies. In general, the celestial motions go on so slowly that their amount during so brief an interval as twenty seconds cannot be certainly detected. Only the moon, the planet Mercury, and Jupiter's satellites move so rapidly that an accumulated error of this amount in our measure of time might be brought to light by them. In the case of Jupiter's satellites we have to depend on the time of their eclipses, and the observations of these phenomena are so far from accurate that no conclusive result has yet been derived from them. But transits of Mercury over the sun's disc have been observed with greater or less accuracy since 1677. The present state of the question is presented in the following tables. The first column gives the mean dates of eclipses or other observations of the moon, and the second the mean excess of her observed mean longitude over that computed from the theory of her motion about these dates. In the third column this excess is given in time, and shows how far we must suppose the actual earth to be in advance of a uniformly revolving earth in order to account for the apparent excess.

I. *Ancient Eclipses.*

Year.	Deviation of longitude.	Time in advance.
	′	m.
B.C. 687	+ 41·0	−76
B.C. 381	+ 12·1	−22
B.C. 189	+ 11·6	−21
A.D. 134	+ 5·2	− 9
846	+ 0·9	− 2
926	+ 3·1	− 6
986	+ 0·4	+ 1

II. *Modern Observations.*

	″	s.
1625	+ 15·7	−26
1650	+ 1·0	− 2
1675	0·0	0
1700	+ 3·7	− 7
1725	+ 7·2	−13
1750	+ 14·5	−26
1775	+ 21·5	−39
1800	+ 21·2	−38
1825	+ 19·7	−36
1850	+ 9·0	−16
1875	0·0	0
1900	− 6·7	+12

These numbers show that either the moon was moving more slowly, or the earth rotating more rapidly, through the whole 19th century, than during the period 1675 to 1775. To decide which was the case we must have recourse to transits of Mercury. The following table shows the excess of the observed times of the ingress and egress of Mercury in November transits over the sun's disc from 1677 to 1894. May transits are omitted, because they were not observed at the earlier dates. The last column gives the weights of the observations.

	Seconds.	Weight.
1666 I	−47	0·1
,, E	+26	0·1
1697 E	−25	0·2
1728 I	− 8	2·5
1736 I	− 9	0·6
,, E	+ 1	0·6
1743 I	0	1·5
,, E	− 3	4·5
1769 I	− 7	2·5
,, E	− 1	0·5
1789 I	+10	3·5
,, E	+ 6	2·5
1802 I	+ 4	6·0
1822 I	+11	0·4
,, E	− 7	2·5
1848 I	+ 7	6·0
,, E	+ 7	0·5
1861 I	+12	2·0
,, E	+11	4·0
1868 I	+ 2	0·6
,, E	− 5	4·0
1881 I	− 6	6·0
,, E	− 2	6·0
1894 I	− 6	6·0
,, E	+ 2	6·0

On the theory that the apparent variations in the motion of the moon really arise from changes in the earth's rotation, the numbers of this table should, in a general way, correspond to those in the last column of the table preceding. Evidently such is not the case, since, if we take the weighted means of the deviations during the three periods 1677-1743, 1769-1822, 1861-1894, the results are :—

	Sec.
Mean date 1737 $\Delta +$ =	−4·5
,, ,, 1795 ,,	+2·4
,, ,, 1880 ,,	+0·6

We are therefore led to the conclusion that either the motion of the moon is affected by some other cause than the gravitation of other bodies, or mathematicians have not yet succeeded in rigorously computing the effect of this gravitation.

Fundamental Astronomical Constants.

The term *constant* is used in astronomy in a relative sense, most of the quantities thus designated being really subject to variation. The term is applied because the variations of these quantities are so slow that the quantities may be regarded as constant for the periods of time over which computations usually extend. Some of these constants, especially those which relate to the motions of the earth and moon, are intimately related to the first principles of gravitational astronomy. We shall develop the fundamental principles of the subject, and show how, by means of them, the values of the constants may be derived.

Units of measure.

We begin by defining the units of those physical quantities which enter into astronomy. It will be remarked that in physics three units are regarded as fundamental or arbitrary, while all others are derived from them by definition. These fundamental units are those of length, mass, and time. In the system now most widely adopted for physical investigation—that known as the C.G.S. system—the centimetre is taken as the unit of length, the gramme as that of mass, and the second as that of time. The same fundamental units of length and time may be introduced in astronomy, but it will be more convenient to take the metre as the unit of length. The passage from the metre to the centimetre, and *vice versâ*, is too simple to require discussion. The second may be taken as the unit of time for our present purpose; but it is more convenient to take the unit of mass as a derived one. The astronomical units will then be as follows :—

The units of time and length are arbitrary, the second and the metre being chosen unless otherwise expressed.

Unit velocity is that which carries a point over unit space in unit time.

The unit of mass is that the gravitation of which acting on an equal mass at distance unity would generate a unit of velocity in a unit of time.

The unit of force is that which would generate a unit of velocity by acting on unit mass during a unit of time.

To distinguish the preceding unit of mass from that of physics it is called the *gravitational unit*.

The physical unit of length, metre or centimetre, can be used in astronomy only to derive the values of certain astronomical constants, because, in practice, it is too short to use in expressing celestial distances. But by the use of logarithms we may extend our physical measures over the celestial spaces without the use of unmanageably large numbers. Yet, in any case, the relations between the terrestrial measure and the distance of the earth from the sun must always remain more or less doubtful. Hence it is necessary to adhere to the usual astronomical unit, namely, the mean distance of the sun, in expressing distances among all the heavenly bodies except the moon.

Gravitational constant.

The relation between the arbitrary physical unit of mass, the gramme for example, and the gravitational unit, is a fundamental problem of physics. To ascertain it we must measure the gravitation exercised by a known mass at a known distance. This will give us the attraction of a physical unit of mass at unit distance, a quantity known as the Newtonian constant of gravitation. Those older methods of determining this constant which rest upon the observed attraction of great masses of matter—mountains, for example—or upon the increase in the force of gravity found on descending into mines, are now entirely superseded, owing to the uncertainty as to the density and arrangement of the masses whose action is measured. Recent determinations depend entirely upon the attraction of portable masses, such as spheres or blocks of lead. It is impossible within the space of the present article to describe in detail the methods by which these determinations have been made. There is probably no other physical experiment involving so many difficulties or requiring attention to such a multitude of minute details. Speaking in a general way, three methods have been applied in recent times. In the first, use is made of the torsion balance, consisting of a light rod suspended by its centre and carrying a ball at each end, which is attracted by leaden masses. This is known as the Cavendish experiment. The apparatus was described in the article on ASTRONOMY in our ninth edition. The apparatus for the application of the second method is a pendulum suspended very slightly above its centre of gravity. This method is new, having so far only been employed by Wilsing of Potsdam. The third method, which is also new, consists in determining the changes in the weight of bodies produced by the attraction of the leaden masses. In the application of this method a change of weight of the small fraction of a millionth part is not only to be made evident, but actually measured; yet it has been successfully carried out by Poynting at the Cavendish Physical Laboratory, Cambridge. Two determinations by this method have also been made in Germany, one by Jolly and the other by Richarz and Krigar-Menzel.

Notwithstanding the extraordinary delicacy of Poynting's work, the torsion balance seems better adapted to the purpose, owing to the horizontal direction of the minute force measured. The results reached by Mr C. V. Boys, F.R.S., at the Clarendon Physical Laboratory, Oxford, and Dr Carl Braun, S.J., at Mariaschein, Bohemia, are wonderfully accordant as well as self-consistent. Defining the gravitational constant as the attraction in C.G.S. units of one gramme of matter at one centimetre distance, they are:—

$$\begin{aligned}\text{Boys: G.C.} &= 6{\cdot}65760 \div 10^8\\ \text{Braun} &= 6{\cdot}65786 \div 10^8\end{aligned}$$

As to accuracy, Boys conceives that his factor 6·6576 cannot be more than 0·001, or at the outside 0·002, in error, while Braun estimates his probable error at ±0·00168. The agreement of the two results is much closer than we should expect from these probable errors, which we may regard as practically equal. The mean result—

$$6{\cdot}65773 \div 10^8$$

may therefore be accepted as the last word on the subject. From this may be derived the mean density of the earth by a process which we shall include in a general determination of the astronomical constants which pertain to the mass, figure, and dimensions of the earth.

Mass of geoid.

The latest complete investigation of the dimensions and figure in question is that of Clarke, to be found in the *Ency. Brit.*, ninth edition, article EARTH, FIGURE OF. With his numbers we give, for comparison, those of Bessel, which are still to a certain extent in use:—

	Clarke.	Bessel.	C – B.
Polar axis .	6356515 m.	6356079 m.	+436
Equatorial axis	6378249 m.	6377397 m.	+852
Ellipticity .	1÷293·46	1÷299·15	

According to Helmert, the most recent measures of arcs in Europe and Asia indicate a diminution of Clarke's ellipticity to Bessel's value, but tend to confirm his larger value of the equatorial semi-axis. The datum which we need for the solution of our problem is the attraction which the earth would exert on a point at its surface if it were a perfect sphere composed of spherical layers of equal density. In deriving this quantity a theorem in the attraction of spheroids is introduced by which the force in question is found to be approximately equal to that of the actual earth at a point the sine of whose geocentric latitude is $\frac{1}{\sqrt{3}}$. For this point we have—

Geocentric latitude	=35° 15′ 52″
Geographical latitude . . .	=35° 26′ 43″

The geometric mean of Clarke's three axes is 6370997 metres. His radius at geocentric latitude ϕ' is

$$\rho = 6367368\text{ m.} + 10868\text{ m.}\cos 2\phi' + 14\text{ m.}\cos 4\phi'.$$

For $\sin\phi' = \frac{1}{\sqrt{3}}$ we then have

$$\rho = 6370980.$$

Helmert's general discussion of the length of the second's pendulum gives for its value in terms of the geographical latitude ϕ,

$$L = 0{\cdot}990918\text{ m. }(1 + 0{\cdot}005310\sin^2\phi).$$

This multiplied by π^2 gives for the intensity of gravity

$$g = 9{\cdot}77997\text{ m. }(1 + 0{\cdot}005310\sin^2\phi).$$

This is the earth's attraction diminished by the vertical component of the centrifugal force, of which the value is

$$0{\cdot}03392\,\rho\cos\phi'\cos\phi.$$

This expression for the force of gravity gives for the actual attraction of the earth at the parallel of 35° 26′ 43″

$$9{\cdot}79743\text{ m.} + {\cdot}02253\text{ m.} = 9{\cdot}81996\text{ m.},$$

which may be taken as the attraction of the whole mass of the earth, if concentrated at its centre or reduced to a sphere, upon a body at distance 6370980 metres. Taking the metre as the unit of length, we have for the mass of the earth in the astronomical units already defined $9{\cdot}81996 \times 6370980^2$, which gives for the total mass of the earth in gravitational measure:

Logarithm of the earth's mass = 14·600522.

If, instead of the metre, we take the centimetre as the unit, we have—

Logarithm of the earth's mass = 20·600522.

In other words, this is the logarithm of the gravitation of the earth's mass at 1 centimetre distance expressed in C.G.S. units. The corresponding attraction of 1 gramme of matter being the number already stated, of which the logarithm is $\bar{8}{\cdot}823326$, it follows that the logarithm of the earth's mass in grammes is

$$20{\cdot}600522 - \bar{8}{\cdot}823326 = 27{\cdot}777196.$$

Clarke's dimensions give for the logarithm of its volume 27·034711. It follows that we have—

Logarithm of earth's density = 0·742485,

whence density of earth = 5·5270.

This conclusion as to density supposes the whole mass included in the geoid. It will be diminished by allowing for the elevation of the continents, and increased if the ocean be excluded from the matter taken into account.

Some of the results for the density found by the other methods are as follows:—

Method of Weighing.

Poynting	D=5·4934
Jolly	„ 5·69
Richarz and Menzel . . .	„ 5·505

Method of Pendulum.

Wilsing	D=5·579

Parallax of the moon.

One of the most important astronomical applications of the preceding results is the determination of the mean distance of the moon from the earth. Knowing the masses m and m' of the earth and moon, and the mean motion n of the latter in one second, its mean distance a follows at once from the well-known equation of the elliptic motion,

$$a^3 = \frac{m + m'}{n^2} = \frac{m(1+\mu)}{n^2}$$

μ being the ratio of the masses. In one second of mean time the moon moves through an arc whose logarithm is 4·425159 – 10. We shall presently find $\mu = 1 \div 81{\cdot}65$, and have just given the value of log. m from the seconds pendulum. We then find from the above equation

$$\begin{aligned}&\log.\ a\text{ in metres} = 8{\cdot}585164\\ \text{whence}\quad &a = 384737\text{ kilometres.}\end{aligned}$$

The motion of the moon is so affected by the action of the sun that this number does not rigorously represent the actual mean distance of the moon. Moreover, what is used in astronomical practice is the horizontal parallax of the moon.

Gravitational theory shows that the constant of this quantity, which we call π_0, is connected with the above value of a by the relation

$$\sin\pi_0 = 1{\cdot}000907\,\frac{\rho}{a},$$

ρ being the diameter of the earth. Using Clarke's equatorial diameter we find:—

Equatorial horizontal parallax of the moon = 57′ 2·76″. This result is in good agreement with that of direct observations.

It is interesting to remark that, if we regard the dimensions of the earth as unknown, observations of the seconds pendulum, combined with measures of the moon's parallax, would enable us to determine them. The form of the equations we have used to determine the earth's mass and the moon's distance show that, if we express the earth's radius in terms of the moon's parallax, it will come out in the form

$$\rho = k\sin^3\pi_0,$$

k being a numerical constant. It follows from this form that the ratio of error in π_0 would be multiplied three times in the resulting value of ρ. As a matter of fact we can determine ρ with greater proportional precision than the parallax, so that the logical course is to determine π_0 from ρ rather than the reverse.

Precession and nutation.

The fundamental gravitational relations on which the motions of precession and nutation depend may be stated as follows:—We put P, P′ = the portions of the lunisolar precession in a Julian year, due to the action of the moon and sun respectively, N = the constant of nutation, μ = the ratio of the mass of the moon to that of the earth, $\mu' = \frac{\mu}{1+\mu}$, A, C = the equatorial and polar moments of inertia of the earth, $q = \frac{C-A}{C}$, a quantity which may be called the mechanical ellipticity of the earth, and ϵ = the obliquity of the ecliptic.

The theory of the moon's motion and of its action on the earth give the following equations:—

$$\left.\begin{aligned} N &= [5{\cdot}40289]\,\mu'\ q\cos\epsilon \\ P &= [5{\cdot}975052]\,\mu'\ q\cos\epsilon \\ P' &= [3{\cdot}72509]\ q\cos\epsilon \end{aligned}\right\}\ (1)$$

In these expressions q and μ' are absolute constants to be determined, while ϵ varies slowly, but is known. The values of N and of P + P′ are given by observation. At a conference of the directors of four national astronomical ephemerides, held at Paris in 1896, it was decided to adopt

$$N = 9{\cdot}210''.$$

By a discussion undertaken at the request of the same conference it was found that, for the epoch 1900,

$$P + P' = 50{\cdot}3722'' \qquad (2)$$

For the same epoch the obliquity is

$$\epsilon = 23^\circ\ 27'\ 8{\cdot}26''.$$

With these numerical values the equations (1) and (2) are four in number, which suffice to determine μ', q, P, and P′ for 1900.

The solution gives the following results:—

	Julian Year	Solar Year.
Lunar precession for 1900	31·3677″	31·3870″
Solar ,, ,, ,,	15·9812″	15·9838″
Lunisolar ,, ,, ,,	50·3719″	50·3708″

$$q = \frac{C-A}{C} = 0{\cdot}0032813$$

Mass of moon ÷ mass of earth = 1 ÷ 81·65.

Obliquity of ecliptic.

Recent research enables us to compute the obliquity of the ecliptic at past and future epochs with an error not exceeding 1″ per century elapsed. The result is shown in the following table:—

Year. B.C.	Obliquity.			Year. A.D.	Obliquity.		
	°	′	″		°	′	″
3000	21	1	16·5	0	23	41	42·4
2900	24	0	44·1	100	23	40	57·9
2800	24	0	11·1	200	23	40	13·1
2700	23	59	37·5	300	23	39	28·1
2600	23	59	3·5	400	23	38	42·8
2500	23	58	28·9	500	23	37	57·4
2400	23	57	53·7	600	23	37	11·6
2300	23	57	18·1	700	23	36	26·1
2200	23	56	41·9	800	23	35	40·2
2100	23	56	5·3	900	23	34	54·1
2000	23	55	28·2	1000	23	34	7·9
1900	23	54	50·6	1100	23	33	21·6
1800	23	54	12·5	1200	23	32	35·2
1700	23	53	34·0	1300	23	31	48·7
1600	23	52	55·1	1400	23	31	2·1
1500	23	52	15·8	1500	23	30	15·42
1400	23	51	36·0	1600	23	29	28·69
1300	23	50	55·9	1700	23	28	41·91
1200	23	50	15·3	1800	23	27	55·10
1100	23	49	34·4	1900	23	27	8·26
1000	23	48	53·1	2000	23	26	21·41
900	23	48	11·4	2100	23	25	34·56
800	23	47	29·4	2200	23	24	47·73
700	23	46	47·1	2300	23	24	0·91
600	23	16	4·4	2400	23	23	14·13
500	23	45	21·5	2500	23	22	27·40
400	23	44	38·2	2600	23	21	40·73
300	23	43	54·7	2700	23	20	51·13
200	23	43	10·9	2800	23	20	7·61
100	23	42	26·8	2900	23	19	21·19
0	23	41	42·4	3000	23	18	34·67

The obliquity was at a maximum about 7200 B.C., or 9100 years ago, when its value was 24° 13′. It will reach a minimum about 9600 years hence, when its value will probably be between 22° 30′ and 22° 40′, but cannot be more exactly stated.

The Solar Parallax.

The problem of the distance of the sun has always been regarded as the fundamental one of celestial measurement. The difficulties in the way of solving it are very great, and up to the present time the best authorities are not agreed as to the result, the effect of half a century of research having been merely to reduce the uncertainty within continually narrower limits. The mutations of opinion on the subject during the last fifty years have been remarkable. Up to about the middle of the 19th century it was supposed that transits of Venus across the disc of the sun afforded the most trustworthy method of making the determination in question; and when Encke in 1824 published his classic discussion of the transits of 1761 and 1769, it was supposed that we must wait until the transits of 1874 and 1882 had been observed and discussed before any further light would be thrown on the subject. The parallax 8·5776″ found by Encke was therefore accepted without question for several decades. Doubt was first thrown on the accuracy of this number by an announcement from Hansen in 1862 that the observed parallactic inequality of the moon was irreconcilable with the accepted value of the solar parallax, and indicated the much larger value 8·97″. This result was soon apparently confirmed by several other researches founded both on theory and observation, and so strong did the evidence appear to be that the value 8·95″ was adopted in the *Nautical Almanac* for a number of years. The most remarkable feature of the discussion since 1862 is that the successive examinations of the subject have led to a continually diminishing value, so that at the present time it seems possible that the actual parallax of the sun is almost as near to the old value of Encke as to that which first replaced it.

Methods of determination.

Five fundamentally different methods of determining the distance of the sun have been worked out and applied. They are as follows:—

I. From measures of the parallax of either Venus or Mars the parallax of the sun can be immediately derived, because the ratios of distances in the solar system are known with the last degree of precision. Transits of Venus and observations of various sorts on Mars are all to be included in this class.

II. The second method is in principle extremely simple, consisting merely in multiplying the observed velocity of light by the time which it takes light to travel from the sun to the earth. The difficulty is to determine the time in question.

III. The third method is through the determination of the mass of the earth relative to that of the sun. In astronomical practice the masses of the planets are commonly expressed as fractions of the mass of the sun, the latter being taken as unity. When we know the mass of the earth in gravitational measure, its product by the denominator of the fraction just mentioned gives the mass of the sun in gravitational measure. From this the distance of the sun can be at once determined by the fundamental equation of planetary motion.

IV. The fourth method is through the parallactic inequality in the moon's motion. This method was described in the ninth edition of the *Ency. Brit.*

V. The fifth method consists in observing the displacement in the direction of the sun, or of one of the nearer planets, due to the motion of the earth round the common centre of gravity of the earth and moon. It requires a precise knowledge of the moon's mass. The uncertainty of this mass impairs the accuracy of the method.

Transits of Venus.

I. To begin with the results of the first method. The transits of Venus observed in 1874 and 1882 might be expected to hold a leading place in the discussion. No purely astronomical enterprise was ever carried out on so large a scale or at so great an expenditure of money and labour as was devoted to the observations of these transits, and for several years before their occurrence the astronomers of every leading nation were busy in discussing methods of observation and working out the multifarious details necessary to their successful application. In the preceding century reliance was placed entirely on the observed moments at which Venus entered upon or left the limb of the sun, but in 1874 it was possible to determine the relative positions of Venus and the sun during the whole course of the transit. Two methods were devised. One was to use a heliometer to measure the distance between the limbs of Venus and the sun during the whole time that the planet was seen projected on the solar disc, and the other was to take photographs of the sun during the period of the transit and subsequently measure the negatives. The Germans laid the greatest stress on measures with the heliometer; the Americans, English, and French on the photographic method. These four nations sent out well-equipped expeditions to various quarters of the globe, both in 1874 and 1882, to make the required observations; but when the results were discussed they were found to be extremely unsatisfactory. It had been supposed that, with the greatly improved telescopes of modern times, contact observations could be made with much greater precision than in 1761 and 1769, yet, for some reason which it is not easy to explain completely, the modern observations were but little better than the older ones. Discrepancies difficult to account for were found among the estimates of even the best observers. The photographs led to no more definite result than the observations of contacts, except perhaps those taken by the Americans, who had adopted a more complete system than the Europeans; but even these were by no means satisfactory. Nor did the measures made by the Germans with heliometers come out any better. By the American photographs the distances between the centres of Venus and the sun, and the angles between the line adjoining the centres and the meridian, could be separately measured and a separate result for the parallax derived from each. The results wero:—

Transit of 1874: Distances; par. = 8·888″.
Pos. angles; „ = 8·873″.
Transit of 1882: Distances; „ = 8·873″.
Pos. angles; „ = 8·772″.

The German measures with the heliometer gave apparently concordant results, as follows:—

Transit of 1874: par. = 8·876″.
Transit of 1882: „ = 8·879″.

The combined result from both these methods is 8·857″, while the combination of all the contact observations made by all the parties gave the much smaller result, 8·794″. Had the internal contacts alone been used, which many astronomers would have considered the proper course, the result would have been 8·776″.

Planetary parallaxes.

In 1877 Gill organized an expedition to the Island of Ascension to observe the parallax of Mars with the heliometer. By measurements giving the position of Mars among the neighbouring stars in the morning and evening, the effect of parallax could be obtained as well as by observing from two different stations; in fact the rotation of the earth carried the observer himself round a parallel of latitude, so that the comparison of his own observations at different times would give the same result as if they had been made at different stations. The result was 8·78″. The failure of the method based on transits of Venus led to an international effort carried out on the initiative of Sir David Gill to measure the parallax by observations on those minor planets which approach nearest the earth. The scheme of observations was organized on an extended scale. The three bodies chosen for observation were: Victoria, 10th June to 26th August 1889; Iris, 12th October to 10th December 1888; and Sappho, 18th September to 25th October 1888. The distances of these bodies at the times of opposition were somewhat less than unity, though more than twice as great as that of Mars in 1877. The drawback of greater distance was, however, in Gill's opinion, more than compensated by the accuracy with which the observations could be made. The instruments used were heliometers, the construction and use of which had been greatly improved, largely through the efforts of Gill himself. The planets in question appeared in the telescope as star-like objects which could be compared with the stars with much greater accuracy than a planetary disc like that of Mars, the apparent form of which was changed by its varying phase, due to the different directions of the sun's illumination. These observations were worked up and discussed by Gill with great elaboration in the *Annals of the Cape Observatory*, vols. vi. and vii. The results were for the solar parallax π:

From Victoria, $\pi = 8\cdot801'' \pm 0\cdot006''$.
„ Sappho, $\pi = 8\cdot798'' \pm 0\cdot011''$.
„ Iris, $\pi = 8\cdot812'' \pm 0\cdot009''$.

The general mean result was 8·802″. From the meridian observations of the same planets made for the purpose of controlling the elements of motion of the planets Auwers found $\pi = 8\cdot806''$. All other methods of directly measuring the parallax fall so far behind this in certainty that we may regard Gill's result as the best yet derived from measurement. But the difficulties of the measures are such that other methods may be yet better and in any case are not to be neglected.

Velocity of light.

II. The velocity of light has been measured with all the precision necessary for the purpose. The latest result is 299860 kilometres per second, with a probable error of perhaps 30 kilometres; that is, about the ten-thousandth part of the quantity itself. This degree of precision is far beyond any we can hope to reach in the solar parallax. The other element which enters into consideration is the time required for light to pass from the sun to the earth. Here no such precision can be attained. Both direct and indirect methods are available. The direct method consists in observing the times of some momentary or rapidly varying celestial phenomenon, as it appears when seen from opposite points of the earth's orbit, the only phenomena of the sort available being eclipses of Jupiter's satellites, especially the first. Unfortunately these eclipses are not sudden but slowly changing phenomena, so that they cannot be observed without an error of at least several seconds, and not infrequently important fractions of a minute. As the entire time required for light to pass over the radius of the earth's orbit is only about 500 seconds, this error is fatal to the method. The indirect method is derived from the observed constant of aberration or the displacement of the stars due to the earth's motion. The minuteness of this displacement, about 20·50″, makes its precise determination an extremely difficult matter. The most careful determinations are affected by systematic errors arising from those diurnal and annual changes of temperature, the effect of which cannot be wholly eliminated in astronomical observation, and the recently-discovered variation of latitude has introduced a new element of uncertainty into the determination. In consequence of it, the values formerly found were systematically too small by an amount which even now it is difficult to estimate with precision. Struve's classic number, universally accepted during the second half of the 19th century, was 20·445″. Serious doubt was first cast upon its accuracy by the observations of Nyrén with the same instrument during the years 1880-82, but on a much larger number of stars. His result, from his observations alone, was 20·52″; and taking into account the other Pulkowa results, he concluded the most probable value to be 20·492″. In 1895 Chandler, from a general discussion of all the observations, derived the value of 20·50″. Since then, two elaborate series of observations made with the zenith telescope for the purpose of determining the variation of latitude and the constant of aberration have been carried on by Professor Doolittle at the Flower Observatory near Philadelphia, and Professor Rees and his assistants at the observatory of Columbia College, New York. Each of these works is self-consistent and seemingly trustworthy, but there is a difference between the two which it is difficult to account for. Rees's result is 20·47″; Doolittle's, 20·56″. This last value agrees very closely with a determination made by Gill at the Cape of Good Hope, and most other recent determinations give values exceeding 20·50″. On the whole it is probable that the value exceeds 20·50″; and so far as the results of direct observation are concerned may, for the present, be fixed at 20·53″. The corresponding value of the solar parallax is 8·777″. In addition to the doubt thrown on this result by the discrepancy between various determinations of the constant of aberration, it is sometimes doubted whether the latter constant necessarily expresses with entire precision the ratio of the velocity of the earth to the velocity of light. While the theory that it does seems highly probable, it cannot be regarded as fully established.

Mass of the earth.

III. The combined mass of the earth and moon admits of being determined by its effect in changing the position of the plane of the orbit of Venus. The motion of the node of this plane is found with great exactness from observations of the transits of Venus. So exact is the latter determination that, were there no weak point in the subsequent parts of the process, this method would give far the most certain result for the solar parallax. Its weak point is that the apparent motion of the node depends partly upon the motion of the ecliptic, which cannot be determined with equal precision. Notwithstanding this drawback the elements of admissible error seem smaller by this method than by any other. The derivation of the distance of the sun by it is of such interest from its simplicity that we shall show the computation.

From the observed motion of the node of Venus, as shown by the four transits of 1761, 1769, 1874, and 1882, is found

$$\text{Mass of (earth + moon)} = \frac{\text{Mass of sun}}{332600}.$$

We have already found in gravitational units of mass, based on the metre and second as units of length and time,

$$\text{Log. earth's mass} = 14\cdot60052$$
$$\text{,, moon's ,,} = 12\cdot6895.$$

The sum of the corresponding numbers multiplied by 332600 gives

$$\text{Log. sun's mass} = 20\cdot12773.$$

Putting a for the mean distance of the earth from the sun, and n for its mean motion in one second, we use the fundamental equation

$$a^3n^2 = M_0 + M',$$

M_0 being the sun's mass, and M' the combined masses of the earth and moon, which are, however, too small to affect the result. For the mean motion of the earth in one second in circular measure, we have

$$n = \frac{2\pi}{31558149}; \text{ log. } n = \bar{7}\cdot29907$$

the denominator of the fraction being the number of seconds in the sidereal year. Then, from the formula

$$a^3 = \frac{M_0}{n^2} = \frac{[20\cdot12773]}{-15\cdot59814}$$

we find

Log. a in metres =	11·17653
Log. equat. rad. ⊕	6·80470
Sine ☉'s eq. hor. par.	5·62817
Sun's eq. hor. par.	8·762″.

The writer regards this as at present the most trustworthy of all the methods of determining the distance of the sun.

Motion of moon.

IV. The determination of the solar parallax through the parallactic inequality of the moon's motion also involves two elements—one of observation, the other of purely mathematical theory. The inequality in question has its greatest negative value near the time of the moon's first quarter, and the greatest positive value near the third quarter. Meridian observations of the moon have been heretofore made by observing the transit of its illuminated limb. At first quarter its first limb is illuminated; at third quarter, its second limb. In each case the results of the observations may be systematically in error, not only from the uncertain diameter of the moon, but in a still greater degree from the varying effect of irradiation and the personal equations of the observers. The theoretical element is the ratio of the parallactic inequality to the solar parallax. The determination of this ratio is one of the most difficult problems in the lunar theory. Using Hansen's determination, the values of the solar parallax derived from three independent series of observations of the moon are:—8·802″ (from Greenwich and Washington meridian observations); 8·789″ (Battermann, from occultations of stars by the moon); 8·767″ (Franz, from observations of a lunar crater). Giving these three results the respective weights 5, 2, and 1, the result is 8·794″. But the most recent and as yet unfinished researches of E. W. Brown and G. W. Hill throw doubt on the precision of Hansen's theoretical ratio. If the latter is corrected by the work of these investigators, the value of the solar parallax derived by this method is reduced to about 8·773″.

Motion of earth.

V. The fifth method is, as we have said, the most uncertain of all; it will therefore suffice to quote the result, which is

$$\pi = 8\cdot818''.$$

The following may be taken as the most probable values of the solar parallax, as derived independently by the five methods we have described:—

From measures of parallax .	8·802″
,, velocity of light . .	8·777″
,, mass of the earth . .	8·762″
,, par. ineq. of moon .	8·773″
,, lunar equation . .	8·818″

The question of the possible or probable error of these results is one on which there is a marked divergence of opinion among investigators. Probably no general agreement could now be reached on a statement more definite than this; the last result may be left out of consideration, and the value of the solar parallax is probably contained between the limits 8·77″ and 8·80″. The value 8·80″ was chosen at the Paris conference of 1896, and is now generally adopted in astronomical ephemerides. The most likely distance of the sun may be stated in round numbers as 93,000,000 miles. It is possible that observations of Eros, the remarkable asteroid of which we have already spoken, may settle the question; but there is no prospect of its being soon settled in any other way.

Variation of Latitudes.

The development of an important feature of the rotation of the earth is due very largely to the investigations of S. C. Chandler. This is a minute periodic change in the point at which the axis of rotation intersects the earth's surface; that is, in the position of the pole of the earth. The result is a variability of the terrestrial latitudes generally.

Dynamical theory.

To make clear the nature of the movement in question we must begin with a statement of some results of theory. Let EQ (see Fig. 2) represent the section of an oblate spheroid through its shortest axis, PP. We may consider this spheroid to be that of the earth, the ellipticity being greatly exaggerated. If it is set in rotation around its axis of figure PP, it will continue to rotate around that axis for an indefinite time. But suppose that instead of rotating around PP it rotates around some other axis, RR, making a small angle, POR, with the axis of figure PP; then it has been known since the time of Euler that the axis of rotation RR, if referred to the spheroid regarded as fixed, will gradually rotate round the axis of figure PP in a period defined in the following way:—If we put C = the moment of momentum of the spheroid around the axis of figure, and A = the corresponding moment around an axis passing through the equator EQ, then, calling one day the period of rotation of the spheroid, the axis RR will make a revolution around PP in a number of days represented by the fraction C/C − A. In the case of the earth we have found that the inverse of this ratio is 0·0032813. It follows that the period in question is 305 days. It has for more than half a century been recognized as possible that the axis of rotation of the earth might not coincide with its axis of figure, and, in consequence, that such a rotation as this might be going on.

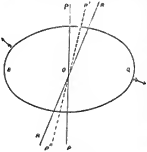


Fig. 2.

The latitude of a point on the earth, as determined by astronomical observations, is determined with respect to the axis of rotation RR, and not with reference to PP, because the latter cannot be fixed by any direct method. Hence, if such a change in this axis were going on, it was supposed that there would be a harmonic variation of the latitudes of all points of the earth's surface in a period of about 305 days. Up to 1890 the most careful observations and researches failed to afford evidence of a rotation in this period, though there was strong evidence of a variation of latitude. Observations for the value of the constant of aberration made at Pulkowa and Berlin between the years 1880 and 1890 seemed to show that the latitudes of those places did actually change from time to time to the amount of about half a second of arc. Chandler, from an elaborate discussion of these and a great number of other observations, showed that there was really a variation of the latitude of the points of observation; but, instead of the period being 305 days, it was about 428 days. At first sight this period seemed to be inconsistent with dynamical theory. But a defect was soon found in the latter, the correction of which reconciled the divergence. In deriving a period of 305 days the earth is regarded as an absolutely rigid body, and no account is taken either of its elasticity or of the mobility of the ocean. A study of Fig. 2 will show that the centrifugal force round the axis RR will act on the equatorial protuberance of the rotating earth so as to make it tend in the direction of the arrows. A slight deformation of the earth will thus result; and the axis of figure of the distorted spheroid will no longer be PP, but a line P′P′ between PP and RR. As the latter moves round, P′P′ will continually follow it through the incessant change of figure produced by the change in the direction of the centrifugal force. Now the rate of motion of RR is determined by the actual figure at the moment. It is therefore less than the motion in an absolutely rigid spheroid in the proportion RP′ : RP. It is found that, even though the earth were no more elastic than steel, its yielding combined with the mobility of the ocean would make this ratio about 2 : 3, resulting in an increase of the period by one-half, making it about 457 days. Thus this small flexibility is even greater than that necessary to the reconciliation of observation with theory, and the earth is shown to be more rigid than steel—a conclusion long since announced by Kelvin, for other reasons.

Chandler's formulæ.

Chandler afterwards made an important addition to the subject by showing that the motion was represented by the superposition of two harmonic terms, the first having a period of about 430 days, the other of one year. In order to state his conclusion we have to express the position of the pole of rotation on the earth's surface relative to the mean pole. Let us represent the fixed position of the latter by O, while P represents the position of the movable pole. We then have to express the position of P relative to O in terms of the time. Let us imagine two co-ordinate axes going out from O—the one towards Greenwich, the other in 90° E. longitude. We represent the co-ordinate in the direction of Greenwich by y, that in the direction 90° E. by x. Then P revolves round O in a direction from west towards east in a curve such that the co-ordinates of P may be expressed in the form:—

$$
\begin{aligned}
x &= r\sin\theta t + 0{\cdot}11''\sin(\odot + 60^\circ)\\
y &= r\cos\theta t + 0{\cdot}11''\cos\odot
\end{aligned}
$$

$\odot$ being the sun's mean longitude, and r and θ quantities which Chandler believes to be slowly variable. He represents the variations in terms of an angle χ having a period of 24,000 days, or a daily motion of 0·015°, of which the value was 0° at the date 31st March 1865. At this date the pole P passed the meridian of Greenwich. If only the first terms of x and y are included, the other dates T of passage—that is, the dates when θt is a multiple of 360°—are by the equation

$$T = 1865{\cdot}25 + 428{\cdot}6^{d}\,E + 55^{d}\sin\chi,$$

E being an entire number, expressive of the number of periods from 1865·25.

He also finds

$$
\begin{aligned}
r &= 0{\cdot}135'' + 0{\cdot}05''\sin\chi\\
\text{Period} &= 428{\cdot}6^{d} + 5{\cdot}26^{d}\cos\chi\\
\theta &= \frac{360^\circ}{\text{Period}}.
\end{aligned}
$$

The angle χ is a purely empirical quantity, introduced to represent past observations. There can be no certainty that it will represent future ones.

If the supposed variation of r and P or θ are unreal, the motion of the angle θt is 0·843° per day, the period about fourteen months, and $r = 0{\cdot}148''$. The expressions for x and y then become

$$
\begin{aligned}
x &= 0{\cdot}148''\sin 0{\cdot}843^\circ t + 0{\cdot}11''\sin(\odot + 30^\circ)\\
y &= 0{\cdot}148''\cos 0{\cdot}843^\circ t + 0{\cdot}11''\cos\odot,
\end{aligned}
$$

the time t being counted in days from the day 2412646 of the Julian period or 1st July 1893. The difference of 30° between the sine and cosine arguments of the annual term shows that this term represents an elongated ellipse.

The variation of the latitude of any place of which the longitude east of Greenwich is λ is given by the formula

$$\phi - \phi_0 = x\sin\lambda - y\cos\lambda$$

ϕ being the instantaneous, and ϕ_0 the mean latitude.

Summary of conclusions.

While there can be no doubt as to the reality of the fourteen-month term, there is not as yet a general agreement as to the amount and nature of the annual term. It is difficult to determine the latter with certainty, because the effect of the diurnal variations of the temperature of the instrument and the atmosphere, which cannot be accurately ascertained and allowed for, might lead to minute apparent terms having a period of a year. The reason of this is, that the observations have to be made upon stars while they are crossing the meridian; in the case of any one star, the transit occurs at all hours of the day in succession in the course of twelve months. For example, a star which at midsummer would be observed at six in the morning would, at midwinter, be observed at six in the evening, when the conditions might be materially different. The present state of the question, so far as theory is concerned, may be summed up as follows:—

(1) The fourteen-month term is an immediate result of the fact that the axes of rotation and figure of the earth do not strictly coincide, but make with each other a small angle of which the mean value is about 0·15″. If

the earth remained invariable, without any motion of matter on its surface, the result of this non-coincidence would be the revolution of the one pole round the other in a circle of radius 0·15″ in a period of about 429 days. This revolution is called the *Eulerian motion*, after the mathematician who discovered it. But owing to meteorological causes the motion in question is subject to annual changes. These changes arise from two causes—the one statical, the other dynamical.

(2) The statical causes are deposits of snow or ice slowly changing the position of the pole of figure of the earth. For example, a deposit of snow in Siberia would bring the equator of figure of the earth a little nearer to Siberia and throw the pole a little way from it, while a deposit on the American continent would have the opposite effect. Owing to the approximate symmetry of the American and Asiatic continents it does not seem likely that the inequality of snowfall would produce an appreciable effect.

(3) The dynamical causes are atmospheric and oceanic currents. Were these currents invariable their only effect would be that the Eulerian motion would not take place exactly round the mean pole of figure, but round a point slightly separated from it. But, as a matter of fact, they are subject to an annual variation. Hence the motion of the pole of rotation is also subject to a similar variation. The annual term in the latitude may be readily accounted for in this way. But it seems unlikely that a motion thus produced should have a sensible eccentricity. It therefore appears at present more likely that the seeming eccentricity of the annual motion is unreal and due to the cause already mentioned.

(4) Six Eulerian periods are very nearly seven years. In consequence, the effect of the annual change is to produce an inequality in the amplitude having a period of seven years. During one part of this period the distance of the two poles is nearly double, being increased to 0·25″ or 0·30″. At another part of the period, three and a half years later, the motion almost ceases. Times of greatest motion were in 1890-92, and again in 1897-99; of least motion about 1894, 1901, 1908, &c.

Besides Chandler, Albrecht of Berlin has investigated the motion of the pole P. The methods of the two astronomers are in some points different. Chandler has constructed empirical formulæ representing the motion, with the results already given, while Albrecht has determined the motion of the pole from observation simply, without trying to represent it either by a formula or by theory. It is noteworthy that the difference between Albrecht's numerical results and Chandler's formulæ is generally less than 0·05″.

Masses, &c., of the Planets and Satellites.

The elements, masses, and other particulars relating to the major planets and their satellites, so far as these were known in 1875, are given in the *Ency. Brit.*, ninth edition, vol. ii. pp. 782-83, and the adopted elements of most of these bodies have been so slightly changed that a repetition of them is not deemed necessary. What we shall now present is a *résumé* of the masses, diameters, and other more important constants which have been worked out to the present time, necessarily limiting our review to what may be considered the best-established results. For ordinary astronomical purposes the masses are not expressed in terms of the gravitational units already defined, but as fractions of the sun's mass taken as unity. This fraction is commonly written in the form $\frac{1}{\mu}$, μ being the number of times that the sun's mass exceeds that of the planet. The masses of the satellites are expressed in the same form in terms of the mass of the primary.

Mercury.

The minuteness of the planet Mercury and the absence of a satellite make the determination of its mass difficult and uncertain. In the new planetary tables issued from the office of the *American Nautical Almanac*, and now most used, μ is taken as 6000000. Other values of the mass are generally less than this, μ ranging up to 10000000 or more. G. W. Hill, from a consideration of the probable density, finds values ranging from 10194200 to 10826200. The uncertainty of the diameter renders this result uncertain; an increase of one-tenth in Hill's adopted diameter, 6·68″, would increase the resulting volume by one-third and the mass by nearly one-half. The value 7500000 seems as likely as any. The best values of the diameter are those found during transits over the sun's disc. Todd, with double-image micrometer, found the value 6·604″ ($\Delta = 1$), and Barnard, with filar micrometer, 6·126″. Both results are liable to be too small from the effects of irradiation. Off the sun's disc, results of measures with the filar micrometer are Lowell at Flagstaff 7·4″, and Barnard at Mount Hamilton 6·14″.

Venus.

The mass of the planet Venus derived from all the observations of the sun and Mercury, and adopted in the new planetary tables, is $\mu = 408000$. It is not likely to be in error by 1 per cent. of its amount. For the angular diameter at distance unity Auwers, from heliometer measures during the transits of 1874 and 1882, found the value 16·820″; Newcomb, from double-image micrometer measures during the transit of 1882, that of 16·88″; Barnard, off the sun from measures near inferior conjunction, 17·397″; and German observers, with the heliometer, 17·30″. This difference between the results of measures on and off the sun might be attributed to irradiation; but it is singular that a comparison of numerous measures made at widely different distances from the earth seems to indicate the anomaly of negative irradiation, the diameters measured at the greater distances being proportionately too small instead of too large.

Moon.

The mass of the moon has been already derived as one of the fundamental constants. The most exact value of the diameter is that derived from the occultations of groups of stars, especially when the moon is totally eclipsed. From occultations of the Pleiades J. Peters found, for the mean semi-diameter 15′ 32·49″; Struve, from occultations during total eclipses, 15′ 32·65″; while the most likely value, as concluded by Peters, is 15′ 32·59″. As the apparent diameter varies with the distance, and can be computed only when the moon's parallax is known, it is common to express the moon's diameter in terms of that of the earth as unity. From the value of the parallax already found, it follows that

$$\frac{\text{Diameter of moon}}{\text{Eq. diam. of earth}} = 0{\cdot}272480.$$

For particulars as to the motion of the moon, see article MOON.

Satellites of Mars.

The motions of the orbital planes and of the pericentres of the satellites of Mars offer interesting problems to both the observing and the mathematical astronomer. These problems have been most successfully attacked by Hermann Struve in a memoir presented to the St Petersburg Academy in 1898. The preliminary results of theory may first be set forth:—

Let M (Fig. 3) be the pole of rotation of Mars, O the pole of the orbit of that planet, and S the pole of the orbit of one of its satellites, all projected on the celestial sphere. The arc OM of the sphere will then be equal to that between the equator of Mars and the plane of its orbit; SO will be equal to the inclination of the orbit of the satellite to that of the planet, and SM to the inclination of the same orbit to the equator of Mars. In consequence of the action of the sun, the pole S moves constantly in a direction at right angles to OS, as shown by arrow *a*; while the ellipticity of Mars gives it a much more rapid motion in a direction at right angles to MS, as shown by the other arrow *b*. The actual motion is the resultant of these two components, and is such as to carry S round in a circle, of which the centre is at a third point F. This centre is the pole of a certain plane called the "fixed plane" of the satellite orbit, which makes but a small angle with the plane of the planet's equator. The position of the plane of Mars's equator relative to the plane of the orbit has been found in two ways—

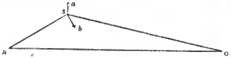


Fig. 3.

from measures on the polar spot, giving the position of the pole of rotation, and from observations of the satellites. The best result of this first method is derived by combining the results of Schiaparelli and Lohse. H. Struve has applied the second. The results are, for the inclination of the equator of Mars to that of the earth,

$$J_0 = 36\cdot42^\circ \text{ (Schiaparelli and Lohse)}$$
$$J_0 = 37^\circ\ 27\cdot1' - 0\cdot239'\ (t - 1880) \text{ (Struve)};$$

and for the longitude of ascending node of equator on that of the earth,

$$N_0 = 48\cdot26^\circ \text{ (Schiaparelli and Lohse)}$$
$$N_0 = 47^\circ\ 5\cdot7' + 0\cdot463'\ (t - 1880) \text{ (Struve)}.$$

Struve also finds, from the motions of the pericentres of the satellites, ellipticity of Mars = 1/190·4; but owing to a doubt as to the revolutions of the pericentre of Phobos, this possibly should be 1/178.

In representing the elements of the orbits of the satellites, the following notation is used:—

J_1, N_1, inclination and node of the "fixed plane" of the satellite's orbit, referred to the earth's equator for the epoch 1880; J, N, the same for the orbit of the satellite; L_0, the mean longitude at the epoch 1894 October, 0·0 Greenwich mean time; n, the tropical mean daily motion; a, the angular semi-major axis of the orbit, as seen from distance unity; π, the longitude of the pericentre on the equator of Mars; e, the eccentricity; K, an angle varying uniformly with the time, whose rate of motion is equal to that of the pericentre, and of the node of the satellite's orbit on the fixed plane; and t, the time in years from 1894·80.

The numerical values of the elements as found by Struve are:—

	Deimos.	Phobos.
K	$29\cdot9^\circ - 6\cdot375^\circ t$	$358\cdot7^\circ - 158^\circ\cdot0t$
J_1	$36^\circ\ 46\cdot5'$	$37^\circ\ 26\cdot7'$
N_1	$46^\circ\ 2\cdot6'$	$47^\circ\ 5\cdot0'$
$(N - N_1) \sin J$	$1^\circ\ 37\cdot6' \sin K$	$0^\circ\ 53\cdot1' \sin K$
$J - J_1$	$1^\circ\ 37\cdot6' \cos K$	$0^\circ\ 53\cdot1' \cos K$
L_0	$186\cdot25^\circ$	$296\cdot13^\circ$
n	$285\cdot16198^\circ$	$1128\cdot84396^\circ$
a	$32\cdot373''$	$12\cdot938''$
π	$231^\circ + 6\cdot375^\circ t$	$272\cdot6^\circ + 158^\circ\cdot0t$
e	$0\cdot0031$	$0\cdot0217$

From the values of a follows:—

$$\frac{\text{Mass of Mars}}{\text{Mass of sun}} = \frac{1}{3090000},$$

Professor Hall's figure, now generally used in astronomy, is 1/3093500.

Schur has measured the diameters of Mars with the heliometer, Barnard with the filar micrometer. The results for the equatorial and polar diameters, as seen from distance unity, are:—

	Equat.	Polar.
Schur	9·526″	9·325″
Barnard	9·673″	9·581″

Each value of the ellipticity is markedly greater than that found by Struve from the motion of the pericentre of Phobos.

Mass of the minor planets.

The minor planets individually are too minute to exert a sensible action on the other planets; but the question whether the mass of the entire group, which may number thousands, can be sufficient to produce an appreciable secular variation of the node and perihelion of Mars is an important one. A rude estimate of the total mass of the group may be made in the following way:—From the stellar magnitude of each known minor planet we may roughly infer its diameter, and hence its probable mass. The statistical law of progressive diminution of the magnitudes or volumes, as derived from the known members of the group, may be extended to the undiscovered members. That a law of progressive diminution extends to the unknown members may be inferred from the fact that, if there were a very great number above a certain limit of magnitude, the whole mass would be visible as a band of light spanning the heavens. The writer has found that by no probable hypothesis as to the number and size of these bodies, consistent with the absence of this band, can the total mass be sufficient to exert any appreciable action on any other planet.

Jupiter.

The mass and diameter of Jupiter can be determined in two ways—by measures of the satellites and by the action of Jupiter on other bodies. The satellites are not well adapted to give an accurate value of the mass, as any proportional error in their mean distances from the planet is multiplied threefold in the result. The following are the results for the reciprocal of the mass reached by different methods, with the weight that may be assigned to each:—

Observations of the satellites	$\mu = 1047\cdot82$	Wt.	1
Action on Fayes's comet (Moller)	$\mu = 1047\cdot79$	,,	1
,, Themis (Krueger)	$\mu = 1047\cdot54$	,,	5
,, Saturn (Hill)	$\mu = 1047\cdot35$	,,	7
,, Winnecke's comet (Haerdtl)	$\mu = 1047\cdot17$	,,	10
,, Polyhymnia (Newcomb)	$\mu = 1047\cdot34$	,,	20

The mean result,

$$\frac{\text{Mass of Jupiter}}{\text{Mass of sun}} = \frac{1}{1047\cdot35 \pm \cdot05}$$

is that now adopted in the planetary tables. In 1901 De Sitter published an important additional result derived from heliometer observations by Gill and Finlay at the Cape Observatory. This was—

$$\mu = 1047\cdot226 \pm 0\cdot067.$$

No definitive changes have been made in the adopted elements of the satellites of Jupiter in recent times.

The measures of the diameter of Jupiter are very numerous, and the differences between the results must be regarded as due to personal equation and peculiarities of instrument rather than to accidental errors. The latest results by the two methods are:—

	Equat.	Polar.
Schur, from observations with the heliometer	37·40″	35·13″
Barnard, from observations with the filar micrometer	38·52″	36·11″

This difference between the results of the two methods appears to be common to all observers, the method of double images always giving a smaller diameter than the micrometer. It may be attributed to a certain softness of outline of Jupiter's disc, which is easily remarked by a careful observer.

Saturn.

The ball, rings, and satellites of Saturn show mechanical features of great interest, not found elsewhere in our system. One of the simplest of these is that the planes of Saturn's equator, of its rings, and of at least its seven inner satellites, have a common secular motion due to the action of the sun. If the latter acted on each of these bodies separately, the secular motions of the planes would be greater the farther the satellite is from the planet, and the motion of the nodes would take place around the plane of the orbit of the planet, the planes of the orbits preserving a nearly constant inclination of almost 27°. The ultimate result of the unequal motion would be that the nodes would be scattered all round the circle, and the planes of the several orbits of the satellites might have mutual inclinations to each other amounting to 53°. But the mutual interaction of the equatorial protuberance of the planet, the rings, and the satellites keeps the motion of the whole system nearly in the same plane, as if it were a rigid body. Especially is this the case with the ring, in the form of which not the slightest deviation from a plane can be detected, whereas, if each of its particles moved independently, the whole would form a mass so broad as to quite conceal the planet from our view.

The most remarkable features of this system are the cases of libration among the motions of the satellites, most of which are quite unique in form. We note for comparison the well-known relation among three of the satellites of Jupiter: if L, L′, and L″ are the respective mean longitudes of the first, second, and third of these bodies, we find that they always move so as to satisfy the equation—

$$L - 3L' + 2L'' = 180^\circ.$$

Let us, for brevity, call W the combination $L - 3L' + 2L''$. It was shown by Laplace that, if W differed slightly from 180°, there would be small residual forces arising from the mutual action of the three bodies, tending always to bring it towards 180°. That is, if W were less than 180°, the force would tend to increase it; if greater, to diminish it, and thus W might swing back and forth on each side of 180° as a pendulum swings on each side of the vertical. This swing would be a libration. As a matter of fact, the swing is too slight to be observed; W stays at 180° as a pendulum might constantly hang in the vertical position.

The similar librations in the Saturnian system have the remarkable feature that not only the mean longitude, but also the longitudes of the pericentres come into ten equations. The first case of this sort noticed was between the sixth and seventh satellites, Titan and Hyperion—the latter being the outer one of the two, and the faintest of the eight known satellites. Its orbit has long been known to be the most eccentric of the system, the eccentricity being 0·10. Professor Hall, by comparing his own observations with those of his predecessors, showed that the pericentre of the orbit performs a complete revolution in about eighteen years in a retrograde direction, this being the reverse of the secular motion due to the action of a disturbing body. It was found that this seeming anomaly arises from a peculiar action of Titan, having its origin in a near approach to commensurability between the mean motions of the two bodies, three times that of Titan being nearly equal to four times that of Hyperion. The motions are so adjusted that if we put L, L′ = the mean longitude of Titan and Hyperion, π' the longitude of the pericentre of Hyperion, and $V = 4L' - 3L - \pi'$, then the angle V will never differ much from 180°, but will continually oscillate on each side of this value, as just explained in the case of the angle W for Jupiter. The annual retrograde motion of π is, from the observations of Hermann Struve, 18·663°, so that the period of its revolution is 19·3 years. The eccentricity of Titan has the effect of making all the elements of Hyperion go through a change in nearly this period, which is determined by the angular distance of the pericentres of the two satellites. The expression for the inequalities thus arising in the eccentricity and pericentre of Hyperion are—

$$\Delta \pi' = 14{\cdot}0^\circ \sin (\pi - \pi')$$
$$\Delta e' = 0{\cdot}0230 \cos (\pi - \pi').$$

The motion in question has also been theoretically investigated by G. W. Hill and Ormond Stone. They have established it to determine the mass of Titan, which is shown to be about 1/4300 that of Saturn itself. This is remarkable, because it seems certain that the angular diameter of the satellite is much less than one second, while that of Saturn when nearest the earth is about twenty seconds. The satellite would therefore seem to be less than 1/10000 the size of Saturn, so that the mass found by Hill and Stone shows its density to be at least twice that of the planet. The masses of the other satellites have been found by Struve to be very minute, varying from 1/250000, in the case of Rhea, to 1/13610000 in that of Mimas.

The determinations of the mass of Saturn have been singularly discordant. They are made by measures of the major axes of the orbits of the satellites and by the action of Saturn on Jupiter. From measures with the heliometer on the brightest satellite, Titan, Bessel found $\mu = 3501{\cdot}6$. A subsequent correction increases the number by one or two units. Leverrier, from the action of Jupiter, found 3529·6 (*Annales de l'Observatoire de Paris*, xii. p. 9). Asaph Hall, from measures of Japetus with the 26-inch Washington telescope, 3481·3 ± 0·54 (*Washington Observations for* 1882, app., p. 70). The small probable error of this last value, the great power of the instrument, and the considerable mean distance of the satellite, more than 500″, would seem to inspire confidence in it. It was strengthened by the use of two quite distinct methods of observing—one with the micrometer, the other by transits giving differences of R. A. between the planet and the satellite. But Hill, from the action on Jupiter, found a result in substantial agreement with Bessel's. To decide the question Asaph Hall, jun., observed Titan with the heliometer of the Yale Observatory, and obtained a result confirming Bessel's. Yet H. Struve, from measures of Japetus and Titan with the Pulkowa 14-inch equatorial, found 3498; and from Titan and the nearer satellites, with the great 30-inch instrument, 3495·3. In Hill's tables of Jupiter, and the other tables of the American Ephemeris, the value 3501·6 is adopted. Still, the preponderance of evidence at the present time seems to favour a number rather below than above 3500.

Uranus and Neptune.

For the angular diameters of Uranus and Neptune Barnard found, with the filar micrometer:—

Uranus, 4·040″ at dist. 19·183
Neptune, 2·433″ „ 30·0551.

The masses adopted in the new tables are:—

Uranus, $\mu = 22869$
Neptune, $\mu = 19314$.

III. THE FIXED STARS.

Our knowledge of the fixed stars has in recent years been widened to an extent which would not have been deemed possible two generations ago. The revelations of the spectroscope have given rise to a branch of astronomy so wide in its scope that it is sometimes regarded as a new science, that of astrophysics—a term now applied to the results of studies on the physical constitution of the heavenly bodies generally, whether the planets or the stars. It is impossible to draw a sharp line between the results of this branch of study and those of the older methods of investigation, sometimes called astrometry, which includes all forms of celestial measurement, whether of distance, motions, or magnitudes; as astrophysics progresses, it necessarily enters this field. Its most remarkable discoveries have resulted from the measurements of motions in the line of sight, the results of which belong strictly to astrometry. Our summary of the advances in stellar astronomy may be introduced by a brief general view of activity in the field at large.

Recent progress.

One prominent feature of recent progress has been the study of the southern heavens. A natural result of the great preponderance of observatories and means of recent research in the northern hemisphere was that, before the present generation, our knowledge of the southern heavens lagged far behind that of the northern ones. When we recall the expedition of Sir John Herschel to the Cape of Good Hope in 1832-34, and the rather limited work of the observatories at the Cape, Melbourne, Paramatta, &c., before 1870, we shall have included the most important researches in this part of the sky. The first step towards a marked extension of our knowledge in this field dates from the foundation of the National Argentine Observatory at Cordoba by Dr Gould in 1871. This observatory has, since its foundation, been devoted to the work of cataloguing and mapping the southern heavens with instruments of precision. The results of this work are found in the splendid volumes, now eighteen in number, published by the observatory. A few years later, Sir David Gill, F.R.S., on his appointment as astronomer of the Cape Observatory, so enlarged the means of that establishment and gave such an impetus to its work that it is now one of the leading observatories of the world. In the field of astronomy his work has differed from that of the Cordoba Observatory in being directed very largely towards the most precise measurements of a limited number of stars, Cordoba having devoted most attention to cataloguing all the stars which could be advantageously reached with the instruments. Gill's most remarkable work has been done with the heliometer, an instrument which he has done much to bring to its present state of perfection. Determinations of stellar parallax have been pursued by him with such success that we have now, so far at least as the brightest stars are concerned, a better knowledge of this subject for the southern heavens than for the northern. Yet more recently the foundation of the Arequipa Observatory, a branch of the Harvard Observatory, has marked an epoch in stellar photometry, to which branch it has been very largely devoted. Through its work, our knowledge of the magnitudes of the stars of the southern heavens now surpasses that of the northern heavens as it was in 1880.

Another prominent feature of the advance we are making has been the application of photography to astronomical investigation. From the time, about 1840, that Dr Draper took a daguerreotype of the moon, up to the year 1882, the photographic art played only a minor part in astronomical work. Perhaps Rutherfurd's work, that of Gould at Cordoba in photographing clusters of stars, the practice of photographing the sun at Greenwich in order to have a record of the changes of its surface, and the application of the art to the transits of Venus in 1874 and 1882, were the most important astronomical applications of photography during this interval. In 1882 Gill, in having the great comet of that year photographed with a portrait lens, found that all the stars in the field of view, down to the 9th or 10th magnitude, were imprinted upon the negatives. Following up the idea thus suggested, he undertook the enterprise of forming by photography a catalogue of all the stars down to the 10th magnitude between the south pole and 23° of south declination. This work has been brought to a completion with the aid of Professor Kapteyn of Groningen, who, with a disinterestedness to which it would be difficult to find a parallel in any other field than that of science, has devoted years of patient toil to the measurements of the positions of the stars on Gill's plates. As a result of this work, and that of Thome, Gould's successor at Cordoba, it may fairly be said that the stars are now even more completely catalogued for the southern heavens than for the northern.

Gill's demonstration, and the use in photography of more sensitive chemicals than had formerly been known, led to the idea on the part of the Paris astronomers of photographing the entire heavens by an international association of observatories. A conference to decide upon the methods of doing this was invited by Admiral Mouchez, director of the Paris Observatory, in April 1887. Here was formulated the plan for the international *Carte Photographique du Ciel*, which was undertaken by some eighteen observatories in both hemispheres. The work is all being done with similar instruments on a uniform plan. The charts in question form two series—one including only the stars down to about the 11th magnitude, the positions of which were to be determined by measurement, so as to form a catalogue, and the other all the stars which could be photographed with the longest available exposure. This work is not yet finished. Some portions of it were undertaken by observatories which appear not to have had the means for its successful prosecution, but other portions have been brought nearly or quite to a completion.

The application of the photographic method has been a prominent feature in the remarkable work of the Harvard Observatory. On assuming the direction of that establishment in 1876 Professor Pickering decided to make astrophysics its speciality. The munificence of those interested in his work has enabled him to command a wealth of appliances almost without example, and to devote to their use one of the largest and best-trained corps of assistants ever engaged in astronomical observation. Before the Paris Conference he had planned a work somewhat similar to that undertaken by the conference and begun to put it in execution. His object was, however, in one point at least, essentially different from that of the international enterprise, for his main idea was to photograph the sky from time to time with a view of detecting at the earliest possible moment any change that might take place among the stars. A striking result of this system has already been mentioned—the discovery of the new planet Eros on a great number of plates taken before the existence of the body was known. Another result has been the discovery of several so-called new stars which have suddenly blazed forth, although, up to the present time, none have become objects that would strike the ordinary spectator. Another speciality of this observatory has been the study of stellar spectra by photography. In this connexion, the aid afforded by the Draper Memorial Fund is worthy of mention. The wealth of material thus accumulated is so vast that its complete publication is scarcely possible. Yet every spectrum photographed is subjected to careful scrutiny, and any remarkable peculiarity that may be exhibited is published and discussed. Photometry has been one of the main branches of Professor Pickering's work, and the volumes already published contain estimates of the magnitudes of stars measured photometrically, now including the entire heavens in the scope of their contents.

Two other important photometric works have appeared which are especially noteworthy, because made with instruments radically different from each other and from that of Pickering. The photometric work of the late Professor Charles Pritchard, F.R.S., at Oxford, was carried out by the use of the extinction wedge, of which a description will be found in the article PHOTOMETRY, STELLAR. The same subject has been a leading feature of the work at the Astrophysical Observatory at Potsdam. The founding of this institution by the German Government soon after the close of the Franco-German war marked an epoch in the development of astrophysics, both because of being contemporaneous with the beginning and early growth of that science and because of the wisdom which has marked its administration. In stellar photometry the special feature of its work has been a very careful determination, by two observers, of a list of stars more limited than that investigated at the Harvard Observatory. The field to be covered includes the hemisphere between the equator and the northern celestial pole. It is divided into zones of 20° in breadth. The zones from the equator to 40° of declination have already been published.

The most remarkable work now done with the spectroscope is the determination of the motions of stars in the line of sight. The earliest attempts at such measures were those made by Sir William (then Mr) Huggins; and after the practicability of making such determinations was demonstrated by him, the work was taken up at the Royal Observatory at Greenwich. In these early researches only optical methods were used which were not susceptible of the highest precision. The introduction of more sensitive chemicals into photographic practice led to the great improvement of photographing the spectra of stars instead of observing them visually. A twofold advantage is thus gained: fainter spectra can be photographed than can be measured with the eye, and the errors to which the eye observations are liable can be almost entirely done away with. The first extended application of the photographic method to this purpose was made by Dr Vogel at the Potsdam Observatory; he measured the motions of forty-eight of the brighter stars in the line of sight with a precision that could not easily be reached by the optical method. The most interesting results of the new system of observation have been the discovery of binary systems among the stars. In this work, Campbell of the Lick Observatory has been remarkably successful; the results reached by him, Deslandres, and others will be summarized in their proper connexion.

Parallaxes and Proper Motions of the Stars.

The methods of determining the parallax of a star are of two kinds. In the one the actual parallax is deduced from the annual change in the right ascension or declination of the star produced by the motion of the earth round the sun, and shown by comparing observations with a meridian instrument of the highest precision. Parallaxes determined in this way are termed absolute. It is now found that, owing to the annual and diurnal changes in the instrument and in the air caused by the varying temperature of night and day, summer and winter, it is impossible to determine precisely, even with the most refined appliances of modern astronomy, variations in the absolute position of a star so minute as its parallax. Efforts to determine absolute parallaxes have therefore been abandoned. The method now in universal use consists in referring the displacement of the star whose parallax is measured to small stars lying in nearly the same direction. The numbers thus obtained are the relative parallax between the star measured and those with which it is compared; and if the stars of comparison are so distant as to have no appreciable parallax, the result will give the actual parallax required. How far this is the case we cannot yet say with certainty; but it is probable that, as a general rule, the stars of comparison have rarely any parallax amounting to a hundredth of a second. In recent times the heliometer has been the most powerful instrument for such determinations; and in the hands of Gill, Elkin, Peter, and others it has been applied in making a revision of many results previously obtained with other instruments, and in investigating suspected new cases of parallax. But at the present time it bids fair to be eventually supplemented or even superseded by the photographic telescope. The great advantage of the photographic method lies in the ease with which a plate can be taken and the leisure with which the images of the stars can be measured upon it; the attempts recently made in this direction seem to show that the precision is not markedly less than that attainable by the use of the heliometer.

It is difficult to make a selection of the stars whose parallax can be said to be determined, but, roughly speaking, we may state the number to be 100. Among these are several cases in which the instrument or method of using it was so imperfect that the results are more or less doubtful, and many others in which the apparent parallax is so minute that it is questionable whether the result may not be due to errors of measurement rather than parallax. Such is undoubtedly the case when the result comes out with a negative algebraic sign, as has happened with some apparently good determinations. The following is a list of the determinations which may be regarded as actual, including all which have been made with the heliometer, even when the result is so minute as to be doubtful. The letter *g* signifies that the result is one of an exceptionally good class reached under Gill's direction by the heliometer of the Cape Observatory. The probable error in these cases is generally between 0·01″ and 0·02″. A colon indicates that the parallax is of a rather doubtful character, needing to be re-determined by modern methods, and two colons that it is among the more doubtful of this class. The results given without any indication may be supposed to be affected by a probable error varying from 0·03″ to 0·05″.

Parallaxes of Stars.

Star.	Position for 1900.		
	R. A.	Decl.	Par.
	h. m.	°	″
β Cassiopeæ . .	0 4	+58·6	·15
Gr. 34 . .	0 13	+43·4	·30
ζ Tucanæ . .	0 15	−65·5	·14
β Hydri . .	0 20	−77·8	·13 g
α Cassiopeæ . .	0 35	+56·0	·01:
η Cassiopeæ . .	0 43	+57·2	·20
γ Cassiopeæ . .	0 50	+60·1	·01:
μ Cassiopeæ . .	1 2	+54·4	·14
Polaris . .	1 22	+88·8	·06
α Eridani . .	1 34	−57·7	·04 g
τ Ceti . .	1 39	−16·5	·31 g
ε Eridani . .	3 16	−43·5	·15 g
50 Persei . .	4 2	+37·8	·04::
o² Eridani . .	4 11	− 7·8	·17 g
α Tauri . .	4 30	+16·3	·11
C. Z. Vh. 243 .	5 8	−45·0	·31 g
α Aurigæ . .	5 9	+45·9	·09
β Orionis . .	5 10	− 8·3	·00 g
α Orionis . .	5 50	+ 7·4	·02
β Aurigæ . .	5 52	+44·9	·06:
α Argûs . .	6 22	−52·6	·00 g
χ⁸ Aurigæ . .	6 39	+43·7	·11
α Can. Maj. . .	6 41	−16·6	·37 g
51 H. Cephei . .	6 53	+87·2	·03:
α Geminorum .	7 28	+32·1	·20::
α Can. Min. . .	7 34	+ 5·5	·30
β Geminorum .	7 39	+28·3	·06
Ll. 15290 . .	7 47	+30·9	·03
ι Urs. Maj. . .	8 52	+48·4	·13:
10 Urs. Maj. . .	8 54	+42·2	·20
Ll. 18115 . .	9 3	+53·1	·18
θ Urs. Maj. . .	9 26	+52·2	·07
Ll. 19022 . .	9 37	+43·2	·06
20 Leo. min. . .	9 55	+32·5	·06
α Leonis . .	10 3	+12·5	·02
Gr. 1618 . .	10 5	+50·0	·18
Gr. 1646 . .	10 22	+49·3	·10
Gr. 1657 . .	10 27	+49·7	·01
Ll. 20670 . .	10 38	+47·7	·01:
Ll. 21185 . .	10 58	+36·6	·46
Ll. 21258 . .	11 0	+44·0	·22
Σ 1516 . .	11 9	+74·0	·15
O. A. 11677 .	11 15	+66·4	·27:
Σ 1561 . .	11 33	+45·7	·03
Gr. 1822 . .	11 40	+48·2	·02
Gr. 1830 . .	11 47	+38·5	·14
Ll. 22632 . .	11 57	+43·7	·00:
Ll. 22810 . .	12 4	+40·8	·06
α Crucis . .	12 21	−62·5	·05 g
β Crucis . .	12 42	−59·1	·00 g

Parallaxes of Stars—continued.

Star.	Position for 1900.		
	R. A.	Decl.	Par.
	h. m.	°	″
β Comæ . .	13 7	+28·4	·11
α Virginis . .	13 20	−10·6	·00 g
β Centauri . .	13 57	+59·9	·03 g
α Bootis . .	14 11	+19·7	·03
α Centauri . .	14 33	−60·4	·75 g
Ll. 27298 . .	14 52	+54·1	·08
α Scorpii . .	16 23	−26·2	·02 g
η Herculis . .	16 39	+39·1	·40 :
π Herculis . .	17 11	+36·9	·11 :
δ Herculis . .	17 11	+24·9	·05 :
ν Draconis . .	17 30	+55·3	·32 :
O. A. 17415 .	17 37	+68·4	·22
70 Ophiuchi . .	18 0	+ 2·5	·19
δ Urs. min. . .	18 • 5	+86·6	·03 :
α Lyræ . .	18 33	+38·7	·11
O. A. 18609 .	18 42	+59·5	·35 :
31 Aquilæ . .	19 20	+11·7	·06
σ Draconis . .	19 33	+69·5	·26 :
α Aquilæ . .	19 46	+ 8·6	·23
α Cygni . .	20 38	+44·9	·00
61 Cygni . .	21 2	+38·2	·39
α Cephei . .	21 16	+62·1	·06 :
ε Indi . .	21 56	−57·2	·27 g
α Gruis . . .	22 2	−47·4	·02 g
α Piscis Austr. .	22 52	−30·1	·13 g
Lac. 9352 . .	22 59	−36·4	·28 g
Br. 3077 . .	23 8	+56·6	·15
85 Pegasi . .	23 57	+26·6	·05

A desideratum of astronomy is a general survey of the heavens with a view of determining all the stars which have an appreciable parallax. Such a survey is now made possible by photography. To carry it out it is necessary to take two or three plates of each region of the heavens at those opposite seasons when the stars in the region have the maximum displacement by parallax in opposite directions. A comparison of the plates then shows whether any such displacement can be detected. The only attempt in this direction which has thus far been carried out was made by Professor Donner at Helsingfors, with the co-operation of Kapteyn, the photographic telescope being that used for the international chart of the heavens. Each plate taken for parallax was exposed three times, at intervals of six months. At the first exposure three images were made on the plate in slightly different positions. At the second, six months later, six images were made in the same way. At the third, a year after the first, three more were made. Thus, twelve impressions of each star were taken, forming together a rectangle of three stars on one side and four on the other. On such a plate the detection of a parallactic displacement is very easy. Unfortunately, only a region little more than 2° square, extending from 20 h. 1 m. to 20 h. 10 m. in right ascension, and from 35° to about 37° in declination, has yet been examined. The plates were carefully measured by Kapteyn. In three or four cases there is some presumption of a parallax of 0·1″, but in no case is it so strongly marked as to be beyond doubt. The probable error of a result from each plate is 0·034″; but it is quite in accord with the theory of probabilities that errors of three or four times this amount should occur in one or more of the results. The extremely limited number of stars having a certainly measurable parallax renders it desirable to find other methods of estimating their distances. It was formerly supposed that the actual magnitude of the stars did not differ greatly from each other, and, if that were the case, an approximate estimate of the distance could be obtained from the apparent brightness. But it is now known that this is so far from the case that brightness alone scarcely affords any clue to the distance of a star. All that we can say with certainty is that, in the general average, the fainter stars are more distant than the brighter ones in a ratio which admits of approximate determination, a statement which tells us nothing about the actual distance of any single star. More information is afforded by the proper motions of which we shall next speak.

Parallactic survey.

The work of cataloguing the stars and determining their exact positions, which is now being pursued on so large a scale, naturally involves the determinations of their proper motions. Every star may be considered as having a proper motion of its own; but the number for which the proper motion has been determined is comparatively small, because, apart from the results of spectroscopic measurements of motion in the line of sight, which are necessarily extremely limited, the motion can be detected only by a comparison of observations taken at long intervals of time. The longer the interval the slower the motion that may be detected. We have now an interval of more than a century in the case of the stars observed by Bradley at Greenwich, about the year 1750-63, and one of the greater part of a century in the case of several other catalogues. From Auwers's discussion of the Bradley stars, 3240 in number, it appears that a little more than one-half of these objects have a proper motion of 5″ per century or more. A little more than one-half of Bradley's stars are easily visible to the naked eye, and the greater part of the remaining half are between the 6th and 7th magnitude. Consequently, the conclusions derived from this work apply only to the brighter stars. Speaking in a general way, we may say that about one-half of these stars are known to have a measurable proper motion. In the case of the fainter stars the proportion would undoubtedly be much smaller than this, but it cannot be exactly stated at present. A few stars have a proper motion so abnormally rapid that it could be detected within a single year. Of these the most rapid known up to a recent time was that of Groombridge 1830, pointed out by Argelander. In 1897 Gill and Innes, at the Cape of Good Hope, found a star of yet greater proper motion. This case was carefully investigated by Kapteyn, who, by a comparison of the Cape photographs and Cordoba observations, found the motion to be the greatest yet known. The following is a list of the stars now known to have a proper motion, exceeding 3″ per year:—

Proper motions.

Name.	R. A. 1900.	Dec. 1900.	Prop. Motion.	Mag.
	h. m.	°	″	
C. Z. Vh., 243 .	5 8	−45·0	8·70	8·5
Gr. 1830 . .	11 47	+38·4	7·04	6·9
Lac. 9352 .	22 59	−36·4	6·94	7·5
Cor. 32416 .	0 0	−37·8	6·07	8·5
61 Cygni . .	21 2	+38·3	5·20	5·7
Ll. 21185 .	10 58	+36·6	4·76	7·3
ε Indi . .	21 56	−57·2	4·61	5·2
Ll. 21258 .	11 0	+44·0	4·41	8·7
o² Eridani .	4 11	− 7·8	4·05	4·6
μ Cassiop. .	1 2	+54·4	3·73	5·6
O. A. 15313 .	15 5	−16·0	3·68	9·1
O. A. 15320 .	15 5	−15·9	3·68	9·1
α Centauri .	14 33	−60·4	3·60	1·0
Lac. 8760 .	21 11	−39·2	3·53	7·3
ε Eridani . .	3 16	−43·4	3·12	4·4
O. Arg. 11677 .	11 15	+66·4	3·02	9·0

This table presents two notable features. One is the minuteness of many of the stars. That the star having the most rapid motion yet known should be below the 8th magnitude is illustrative of the great range of absolute brightness among the stars. The other feature is that two fourths of the circle of right ascension, namely, those from 5 h. to 11 h. and from 15 h. to 21 h., scarcely contain any of the sixteen stars, except at their limits. This may be attributed to the effect of the solar motion in exaggerating the apparent motion of stars far from its apex.

A desideratum of the present time is an exact knowledge of how many stars in the heavens have a measurable proper motion, or, in greater detail, how many have proper motions of each order of magnitude. The data for completely solving this question are still wanting, but the most complete attempt in this direction is that of Anwers, who observed the zone of the "Astronomische Gesellschaft," 15°-20°, at Berlin. He made a comparison of the 8000 stars in his zone with the older observations as far as they were available, and the result was the discovery that 1200 of the stars had proper motions large enough to be detected. Assuming that in the whole heavens the number is proportional to the area, we may regard it as probable that 20,000 stars have a proper motion, extending 5" per century. Several astronomers have made catalogues of stars having exceptionally large proper motion; the most thoroughly worked up of these catalogues is that of Porter for 1890, *Publications of the Cincinnati Observatory*, No. 12, but Bossert's in the *Paris Observations* for 1890 contains more stars—2575 in all.

Solar motion.

That our sun is to be included among the stars having a proper motion has long been inferred from an apparent motion of the stars in the opposite direction, called the parallactic motion. If we regard the general mean position of the mass of stars as at rest, our solar system is relatively to this mean moving toward a point, now known as the Solar Apex, which was long supposed to be situated in the constellation Hercules. Although the approximate situation of this point has been known since the time of the elder Herschel, yet its exact determination is a matter of extreme difficulty, owing to the diversity of the actual motions of the stars and the irregular distribution of those which have been determined. In the following summary of the results of recent researches, we put A for the right ascension of the apex and D for its declination. Professor Lewis Boss, from 279 stars of large proper motion in the zone 1° to 5°, derived A = 283·3°; D = +41·1°. This result might be seriously influenced by the introduction of stars of abnormally large motions; had he excluded twenty-six motions exceeding 40" per century, the result would have been A = 288·7°; D = +51·5°. Porter of Cincinnati, and Stumpe of Berlin, have each made determinations based on all the well-determined proper motions available at the time. Porter's list included 1300 stars, Stumpe's 996, the greater number of the stars being common to the two lists. Each investigator classified his material according to the proper motions of the stars. Stumpe excluded all motions less than 16" or greater than 128" per century. Between these limits they were divided into three groups: Group I., from 16" to 32"; II., from 32" to 64"; III., from 64" to 128". The separate results were:—

Group	I.	(551 stars)	A = 287·4°;	D = +45·0°
,,	II.	(339 ,,)	287·2;	43·5
,,	III.	(106 ,,)	290·2;	33·5

Porter (*Ast. Jour.* xii. p. 89) divided his proper motions into four groups: I., those less than 30"; II., those between 30" and 60"; III., those between 60" and 120"; IV., those exceeding 120". The results were:—

Group	I.	(576 stars)	A = 281·9°;	D = +53·7°
,,	II.	(533 ,,)	280·7;	40·1
,,	III.	(142 ,,)	285·2;	34·0
,,	IV.	(70 ,,)	277·0;	34·9

All three of these agree in the general conclusion that the smaller the proper motions used the greater the declination of the resulting apex, and, in a less degree, the greater its right ascension. But this conclusion needs farther examination before it can be accepted as fully established. Some doubt is thrown upon it by the fact that the position of the solar apex from all the stars of Bradley's catalogues having a small proper motion is A = 274·2°; D = +31·2°. The discrepancy, especially in the declination of the apex, is far outside the normal limits of error on any probable hypothesis, and suggests the necessity of a more thorough examination of the question than has been made. The general conclusion which may be drawn from these results is that our system is moving toward the constellation Lyra, not Hercules. The point is probably near right ascension 280° and declination +38°; but there is an uncertainty of several degrees in this position which cannot be removed until an improved method is applied.

Speed of solar motion.

An important and interesting point is that of the speed of the motion. The most obvious method of determining this is through the apparent parallactic motion of the stars whose parallaxes have been actually measured. When we see a star at a known distance moving away from the sun's apex with a given angular velocity, the transformation of this given velocity into a linear velocity is extremely simple, and gives the relative velocity between the sun and star. The measure of these results from all the stars included will give the speed of the sun relative to their mean position. In this way, from the list of stars whose parallaxes have already been given, it would follow that the speed in question was 6 radii of the earth's orbit in a year, which would correspond to nearly 28 kilometres per second, about that of the earth in its orbit. But this result has an unavoidable defect arising from the fact that the stars selected for measures of parallax have been those having large apparent proper motions. A star whose actual motion is in the opposite direction to that of the sun will have a large apparent motion, while one moving towards the solar apex may have little or no apparent motion, though its actual angular motion may be the same. In consequence, the selection is biased by including mainly those stars whose absolute motion is away from the apex. Consequently, the result is too large. The speed in question can also be derived from the observed motions in the line of sight or radial motions. Kapteyn has done this by a statistical method. From a study of the apparent angular motions of the stars can be derived the ratio between the velocity of the sun and the mean velocity of the stars in general. This mean velocity is found in linear measure from the observed motions in the line of sight, and its product into the ratio derived from the angular motions gives the actual linear velocity of the sun. The resulting speed of the sun's motion was, in round numbers, 16 kilometres, or 10 English miles, per second. This result is now superseded by a recent research of Campbell, based on 280 radial motions (*Astrophys. Jour.* January 1901), giving a speed of 19·89 ± 1·92 km. This speed is almost exactly 4 radii of the earth's orbit per year.

It will be seen that the apparent proper motion of a star is made up of two components—the actual motion relative to the mean of all the stars, sometimes called the *motus peculiaris*, and the parallactic motion, which is only apparent, being due to the motion of the sun. It has been shown by Stumpe that, when we take a large number of stars and classify them according to their total proper motions, the ratio of the parallactic motion to that peculiar to each star is nearly the same for large and for small motions. The former is proportional to the sine of the angular distance of the star from the apex divided by its distance from the earth. It follows from the approach to uniformity in the ratio that the peculiar motions of the stars are also, in the general mean, inversely proportional to their distance from us. Consequently, the actual mean linear velocity of the motion may be taken as the same for stars of various distances, so that the apparent motion will be inversely as the distance. Of course this equality in the general mean by no means implies any approximation to equality in the case of individual stars; yet there is some reason to believe that it is only in exceptional cases that the linear velocity of motion of the stars exceeds a certain limit which it is difficult to fix with precision, but which may be estimated at 40 or 50 kilometres per second. To such a limit there are two remarkable exceptions, one of which has been known for some time, while the other is of recent discovery. Although the proper motion of the star 1830 Groombridge, is, with one exception, the greatest of any known, measures of its parallax show that it is by no means among the nearer stars. The combination of the parallax already given with the observed motion indicates a component of linear velocity perpendicular to the line of sight amounting to about 240 kilometres per second. The recent measures of Elkin on the parallax of Arcturus indicate that its linear velocity is probably nearly as great as and possibly much greater than that of the Groombridge star. The parallax found by Elkin was 0·016″; but in view of the fact that other measures, though far less trustworthy, have given a larger value in the table, 0·03″ has been assigned as the most probable parallax. This gives a linear velocity of some 350 kilometres per second.

Law of proper motion.

One of the most interesting questions growing out of the proper motions of the stars is whether there is any general law among them which indicates that they move in definite orbits and that the universe as a whole forms a stable system. Up to the present time nothing in the way of a general law has been discovered. In a few cases, some of which are mentioned in the original article in the ninth edition of the *Ency. Brit.*, stars in the same region are found to have a common proper motion, indicating that they may form a system among themselves, but these cases are so exceptional as to prove nothing: the general rule seems to be that the proper motion of a star has no connexion with its location in space or its relation to the universe in general. On no probable hypothesis that we can make respecting the mass of the stars could the attraction of all the known bodies of the universe hold either Arcturus or 1830 Groombridge in an orbit.

Variable Stars.

The study of variable stars has in recent times, in connexion with measures of motions in the line of sight, opened up a new and interesting branch of Sidereal Astronomy, and the number of these objects which have been made the subject of accurate observation is now so great that a classification according to the law and period of the variations is possible. The statistical basis on which such a classification must begin is found in Chandler's catalogues, of which the third was published in the *Astronomical Journal*, vol. xvi. Omitting from our consideration η Argus and other irregularly variable stars, as well as the so-called new stars, we find in that catalogue 280 periodic stars, properly so called; that is, such as go through all their changes in a definite period. Classifying the periods according to the length, we find them to be as follows:—

Periods.	Stars.
Less than 50 days	63
50 to 100 ,,	6
100 ,, 150 ,,	9
150 ,, 200 ,,	18
200 ,, 250 ,,	29
250 ,, 300 ,,	40
300 ,, 350 ,,	44
350 ,, 400 ,,	44
400 ,, 450 ,,	18
450 ,, 500 ,,	6
500 ,, 550 ,,	1
550 ,, 600 ,,	1
600 ,, 650 ,,	1

The most suggestive feature of this table is the well-marked limitation of the period. From the maximum of about 350 days, the number of periods having a given length continually falls off until we reach 610 days. This is the longest yet known. It follows that there is something in the constitution of these bodies, or in the cause on which their variation depends, which limits the period. It was formerly supposed that the eleven-years period in the magnitude and frequency of spots on the sun made the sun a variable star; in fact, that the periodicity of the stars might be due to the same cause as that of the solar spots. But the great length of the sun-spot period, taken in connexion with this limitation, seems to disprove the analogy. Passing up towards the other end of the table we are struck by the rapid falling off towards the limit of 50 days and the great number less than 50 days. It might seem that we have here a sharp line of distinction between the two classes—those of long and those of short period. But an examination of the periods in detail does not show any such line. Eight periods are less than 1 day, and about 40 between 1 and 10 days, and from this point up to 100 days they are scattered with a fair approach to uniformity.

The law of change of a periodic star may be represented graphically by a curve. A straight horizontal line or axis of abscissæ is taken to represent the time, and on it equal spaces represent equal times. At each point upon it an ordinate is erected proportional to the amount of light emitted by the star at the corresponding moment. A curve through the ends of these ordinates is the light curve of the variable star. It will be readily seen that, in the case of a star of constant brightness, the ordinates will all be equal, and the curve will be a straight horizontal line. Whatever the law, if the star be a periodic one, the ordinate will return to the same value at the end of a period, and the continuance of the curve through successive periods will be repetitions of the curve corresponding to the first period. It is therefore only necessary to continue the curve through a single period.

A classification of variable stars has been facilitated by the discovery of the cause of variation in certain classes of the stars of shorter periods. The most distinctive class of such stars are those which remain constant during the greater part of the period, and then temporarily lose a portion of their light, soon to recover it again. The brightest and longest-known of this class being Algol or β Persei, stars which vary in this way are said to be of the "Algol type." The curve of such a type is a straight line with a depression at the end of each period. This feature strongly distinguishes the type from those in which the variation, whatever its law, is continuous, for in those cases, which include a great majority of variable stars, the curve is nowhere a straight line.

Algol type.

The great development of the subject in our times began with the discovery of the cause of the change in the case of stars of the Algol type. Ever since the variability of Algol was observed, it was suspected to be due to a partial eclipse of the star by the interposition of a dark body nearly as large as the star revolving around it; but this explanation remained only a surmise until Vogel of Potsdam, by repeated measurements of the motion of Algol in the line of sight, showed that the star is always receding from us before the loss of light, and approaching us afterwards. This was so exactly the result that would be produced by the revolution of such a body as that supposed that no doubt could remain on the subject, and by a legitimate induction the variations of all stars of the Algol type are now assumed to be partial eclipses caused by the interposition of a dark companion moving around them. The number of stars of this class is small, only about twelve being yet known. This may be partly due to the difficulty of detecting variations of the type. Owing to the temporary character of the loss of light, the magnitude of such a star might be observed a great number of times without the variation being detected, since it would be noticed only when the observation happened to be made during the partial eclipse. The following list shows the main particulars relating to stars of this type, their positions, periods, magnitudes, and loss of light when eclipsed:—

Variable Stars of the Algol Type.

Name.	Position.		Period.	Magnitude.		Diminution.
	R. A.	Dec.		Usual	Min.	
	h. m.	°	d. h. m.			
U Cephei	0 53	+81·3	2 11 49·6	7·1	9·2	2·1
β Persei	3 2	+40·6	2 20 48·9	2·3	3·5	1·2
λ Tauri	3 55	+12·2	3 22 52·2	3·4	4·2	0·8
R Can. Maj.	7 15	−16·2	1 3 15·8	5·9	6·7	0·8
S Cancri	8 38	+19·4	9 11 37·8	8·2	9·8	1·6
S Antliæ	9 28	−28·2	0 7 46·8	6·7	7·3	0·6
S Velorum	9 29	−44·8	5 22 24·4	7·8	9·2	1·5
δ Libræ	14 56	− 8·1	2 7 51·4	5·0	6·2	1·2
U Coronæ	15 14	+32·0	3 10 51·2	7·5	8·9	1·4
R Aræ	16 31	−56·8	4 10 12·7	6·9	8·0	1·1
Z Herculis	17 54	+15·1	3 23 49·8	7·1	8·0	0·9
RS Sagittarii	18 11	−34·1	2 9 58·0	6·4	7·5	1·1
Anonymous	19 43	+32·5	3 0 8·8	10·8	12·9	2·1
Anonymous	20 4	+46·0	4 18 45·0	9·0	11·7	2·7
W Delphini	20 33	+17·9	4 19 21·2	9·5	12·0	2·5

β Lyræ type.

Another but analogous type of variation is that of β Lyræ. The characteristic of this type is that in each period there are two equal maxima and two unequal minima. The variation of light is seemingly continuous. G. W. Meyers (*Astrophysical Journal*, vii.) has offered a theory of this type of variation which explains the phenomena so precisely that we cannot seriously doubt its correctness. Two unequal bodies, so near together as to be almost in contact, revolve round each other. By their mutual attraction and the centrifugal force they are drawn out into prolate ellipsoids, each rotating in the same period as that of revolution, so that they revolve as a single mass. Each star partially or wholly eclipses the other in each revolution. When the line of centres is at right angles to our line of sight, the two bodies present to us their greatest apparent surface, and therefore send us their maximum of light. As the line becomes oblique from the revolution they are seen more and more foreshortened, and consequently diminish in brilliancy. Were the two bodies of equal surface brilliancy, the apparent magnitude of minimum would be the same whichever was eclipsed. The inequality of the alternate minima indicates a difference in magnitude and brilliancy. It will seem that this type resembles the Algol type in that the variations of light are due to the different aspects under which a pair of stars is seen as they revolve around each other, and especially by one star of the pair eclipsing the other, and not by any actual changes in the bodies themselves. It is now found that the two types merge into each other by insensible gradations. The principal intermediate type is one in which, calling the two stars A and B, A eclipses B and B eclipses A at each revolution. In such a case, if the orbits were quite circular, it would be impossible by eye-observation alone to distinguish this type from the Algol type, in which the eclipsing body is dark. But if the orbit is eccentric the alternate minima will occur at unequal intervals. Even if such is not the case, the period may be detected by spectroscopic measures of velocity in the line of sight, if only the star is bright enough to admit of its motion being determined in this way.

Systems of Stars, Clusters, and Nebulæ.

Binary systems.

Since 1880 there have been discovered great numbers of double stars, now more properly known as binary systems, which had formerly escaped detection, owing to the difficulty of ascertaining their character with telescopes less perfect than those of our time. Few general facts, however, have been brought out by these discoveries. The advance of our knowledge has mainly consisted in the more accurate determination of the elements of the orbits and the times of revolution of those systems whose period of revolution is less than a century. The trend of recent research is towards extending the conception of systems of stars almost indefinitely in two opposite directions. Since, with every increase of telescopic power, closer binary systems of shorter and shorter periods are found in constantly increasing numbers, we cannot set any limit either to the actual minuteness of such objects or to the shortness of the period. Far within the limit to which telescopic vision can ever extend, such systems are now being brought to light by the spectroscope. These systems appear as a connecting link between certain variable stars on the one hand and the telescopic double stars on the other. Stars of the class to which the Algol type of variables belongs will appear to us to vary in brightness only in the very exceptional cases when the plane of the orbit which one body describes around the other passes so near our sun that the one seems to pass over the other, and so causes an eclipse. In all cases, except those in which the line of sight is nearly perpendicular to the plane of the orbit, the revolution of the two bodies around their common centre of gravity will result in a periodic variation of the motion of each in the line of sight. Such a motion may be detected by the spectroscope. If only one of the two bodies is luminous, its motion will be shown by a periodic change in the displacement of its spectral lines. This, so far as yet known, is the usual case. If both are luminous, especially if they do not differ much in brightness, the motion of revolution will be shown by a periodic doubling of the lines. When, were they visible, they would appear to us in conjunction, their spectra are merged into one, which will show nothing unusual; but if one is moving from us and the other towards us, the spectral lines will be displaced in opposite directions, so that all of the lines strong enough to be seen in both spectra will appear double.

But while there is thus no well-defined inferior limit to the dimensions of systems of two stars, recent research shows that we cannot set any superior limit to the number of stars which may form a system or to the dimensions of such a system. Considering those binary systems whose components are distant from each other, we may, at the first step, meet with a difficulty in deciding whether two stars apparently near each other really form a system, or appear to us together because they happen to be in the same line from us. If their distance is a very few seconds, the presumption would be in favour of a physical connexion. At greater distances the only evidence yet available is found in their relative motion. If the smaller star shares the proper motion of the brighter one, the evidence of connexion is nearly conclusive. If it does not, we assume that they are simply two isolated stars. In the article ASTRONOMY (*Ency. Brit.* vol. ii. p. 820) it was shown that five stars of Ursa Major have a common proper motion, all moving nearly in the same direction and with equal velocity. But though no other case like this has yet been discovered, there are several cases of pairs of stars near each other betraying a relationship by their proper motion, which would never have been suspected on any other ground. The two most remarkable cases of this sort are—(1) a pair of stars in R. A. 15 hours 4 minutes Dec. − 15° 54′, five minutes apart, and (2) A Ophiuchi, which has a star of the same proper motion following it about 13′. It is not unlikely that pairs like these form binary systems with very eccentric orbits and long periods of revolution.

Star clusters.

It does not now appear that we can draw any sharp line as regards numbers of stars between the binary systems which we have been considering and clusters whose components are too numerous to be counted. Triple or quadruple stars have long been familiar; of the latter θ Orionis in the great nebula of Orion affords a typical example. In this case two other stars much more minute belong to the system. Sometimes it is possible to make an actual count of the stars in a cluster, as is the case with Præsepe, in Cancer, which appears to the naked eye as a nebula, and which the telescope shows to be composed of a definite number of comparatively bright stars. We have also such agglomorations as the great cluster of Hercules, where a complete resolution into stars is just possible with the best telescopic power yet reached. The application of photography to these objects has thrown much light on their general character. Many of them have been photographed at the Harvard Observatory, but even there it has not always been possible to separate all the individual stars in the densest clusters. Perhaps the most remarkable feature brought out has been the great number of variable stars in some of the clusters. The following statement is extracted from a Harvard circular:—

Cluster.	Stars examined.	Number of variables.
ω Centauri	3000	125
Messier 3	900	132
Messier 5	900	185

In all 509 variable stars were found among 19,050 examined in twenty-three clusters, a number which exceeds that known to exist in the rest of the sky. Perhaps the most interesting questions suggested by these cluster systems is that of their stability. On any probable hypothesis that we can make as to the constitution of the individual stars, their mutual attraction must be such as would bring them into a single mass in the course of a few thousand years. Why, then, have they not condensed into such a mass? Perhaps the most plausible answer that can now be made is that the individual stars are all moving in irregular orbits under their mutual attraction. If such be the case, the motion would be made manifest by the comparison of photographs taken at intervals of twenty, fifty, or 100 years.

Nebulæ.

The questions which have arisen in our time respecting the constitution of various nebulæ, the changes which they may undergo, their individual forms, and their relations to the stars seen among them, are so numerous that no discussion of them is possible within our present limits. The greatest addition to our means of knowledge has been made, as in many other cases, by the application of photography. Here the works of Dr Isaac Roberts, F.R.S., and Dr A. A. Common, F.R.S., are worthy of special study; their results are for the most part to be found in the publications of the Royal Astronomical Society. One fact brought out quite recently is the superiority of the reflecting telescope over the refractor in this connexion, owing to the absence of chromatic aberration which, even in the secondary character it assumes in the best refracting telescopes, is very appreciable in the long exposures necessary. The great advantage of photography is due to the fact that, in a clear dark sky, it is possible to obtain images of objects which escape vision. This is the case not only with the smaller stars, but apparently in a still higher degree with the nebulæ. Among the most remarkable objects brought out by photography is a great nebulous mass winding through a considerable portion of the constellation Orion, first discovered by W. H. Pickering, and afterwards confirmed by Barnard. Among other remarkable nebulosities of this sort is one in the region of ρ Ophiuchi, photographed by Barnard in 1894; while a third is the singular nebulosity surrounding the Pleiades, carefully studied by Barnard (*Monthly Notices R. A. S.* January 1900). Quite recently a surprising number of new nebulæ have been photographed by the Crossley reflector of the Lick Observatory. Professor Keeler concludes that, judging from the number of these objects brought out with this instrument, there must be as many as 100,000 in the heavens, an average of between two and three to every square degree. It would, therefore, scarcely be an overstatement to say that the heavens are to be regarded as filled with nebulæ. The spectrum of these objects (see *Ency. Brit.* vol. ii. p. 821) seems to show that they are gaseous in constitution, as it consists almost wholly of a very small number of bright lines. An apparent exception is afforded by the great nebula of Andromeda, which gives a continuous spectrum; but in interpreting such a spectrum it must be noted that a gaseous mass gives a bright line spectrum only when it is transparent through and through. If the mass is of such size that a ray of light cannot pass through it the spectrum will, in general, be continuous, like that of a solid body. If the superficial portions are cooler and more tenuous than the interior, the continuous spectrum will be crossed by dark lines, as in the case of an incandescent body surrounded by a cool atmosphere. We conclude, therefore, that the continuous character of the spectrum of the Andromeda nebulæ does not prove it to be composed of solid particles. The transparency of the nebulæ in general, which would be evident even without spectroscopic analysis, shows how extremely tenuous these masses are. We cannot seriously doubt that as a general rule their distances from us are at least as great as those of the fixed stars, possibly much greater. In dimensions the most compact of them must far exceed our whole solar system; probably the great majority, even if we omit the diffused masses to which we can assign no definite outline, may exceed the diameter of the orbit of Neptune a hundredfold. Yet we have reason to believe that a ray of light would not suffer any sensible absorption, except selectively, in passing through them.

Constitution of the Stars and Structure of the Heavens.

Stellar evolution.

The view that the sun and stars are not bodies fitted to exist for ever in their present form is strengthened by all recent researches on their constitution. They are now regarded as bodies of intensely hot matter in the gaseous state, continually losing energy by the radiation of their heat into space, and therefore contracting in volume. This view was first developed by J. Homer Lane in a paper published about 1865 in the *American Journal of Science*; but his results were merely embodied in mathematical formulæ, and not stated with such distinctness as to command attention at the time.

More recently Ritter has developed the subject with great fulness in a series of papers published in the Leipzig *Annalen der Physik und Chemie*. As we have not room for even an abstract of these researches, we can state only what seem to be the most obvious conclusions. That the sun and stars are masses of gas is shown not only by their density, so far as ascertained, but by the fact that solid or liquid masses would cool with such rapidity that they would cease to shine at the end of a few centuries. The superficial portions would first cool and eventually become solid. It was shown by Lane that a mass of gas, held in equilibrium by the mutual attraction of its parts, grows hotter through the loss of energy by radiation, because the temperature gained by the resulting contraction exceeds that lost by the radiation. The effect is analogous to that of a resisting medium upon a planet. The direct result would be to retard the motion of the planet, so that it would fall nearer to the sun, but the velocity gained by the fall would exceed that lost by the resistance. As a planet would go faster by being resisted, so the temperature of a gaseous mass like a star rises as it contracts in volume. This rule ceases to hold when the attraction has become so great that liquefaction takes place, and then the radiation of light by the body is nearly at an end. Another result of the theory is that the greater the mass of a star the higher will be its temperature in a given stage of its development. There may, therefore, be a wide range among the temperatures of the stars, the older and the larger ones generally being the hotter.

The volume of a star is so great that its interior, though gaseous, is not transparent, and it therefore radiates heat only from its superficial portions. These are thus subject to a rapid cooling process; they probably liquefy or solidify, and then by their superior gravity sink into the interior and are replaced by gaseous masses from the interior. Thus a circulation is constantly going on, the hot matter of the interior rising to the surface, and the cool matter of the surface sinking to take its place. A star cannot radiate heat more rapidly than the heat is supplied by this process; consequently, the superficial temperature is limited by the rapidity of circulation, which cannot go on at more than a definite rate, depending on the temperature and the nature of the gas. A necessary result of this view is that each star is constantly contracting in volume, and must continue to do so until the interior becomes liquid or solid. At this stage the increased friction resisting the circulation will result in a continuous fall of the temperature of the surface, which in process of time must cease to radiate light. Recent discoveries give colour to the hypothesis of evolution implied in this view of the physical constitution of stars in general. Their agglomeration into systems is what we should naturally expect as the result of the condensation of irregular nebulous masses.

Density of the stars.

One of the most suggestive conclusions of recent science is that the stars differ greatly in density, and that, in the large majority of cases, the brighter ones at least are much rarer than the sun, probably even of gaseous density. In the case of the Algol type of variable stars we can, by the comparison of the duration of the eclipse with the periodic time, form an approximate idea of the size of the star. If the elements of the orbit can be determined, the mass will also become known, and thus we may form an idea of the density. So far as this method has been carried out, the conclusion is that already stated. Revolving double stars, when the elements of the orbit become known, afford evidence that points in the same direction. Knowing the parallax of a star and the elements of the orbit of a companion moving around it, we can determine the mass of the two bodies. Their absolute brilliancy compared with that of the sun is also known from the parallax and the apparent brilliancy; and it is thus found that, while the mass of Sirius is a little more than double that of the sun, it emits some thirty times as much light. It is now known that a relation between the mass and brilliancy of a double star can be derived from the elements of the apparent orbit without a knowledge of the star's distance. Were all these bodies of the same density and the same intrinsic brilliancy per square mile of surface as the sun, then to every star of a given apparent magnitude, whatever its distance, would correspond a certain relation between the periodic time and the apparent mean distance of a companion revolving around it. Assuming the distance of the companion to be 1", its period on this hypothesis is shown for stars of various magnitudes in the following table:—

Magnitude.	Period.	Magnitude.	Period.
	y.		y.
0	0·9	4	14·1
1	1·8	5	28·2
2	3·6	6	56·2
3	7·1	7	112·0

If the apparent mean distance is different from 1" the time of revolution is given by Kepler's third law in the form $T^2 = T_1^2 S^3$, S being the mean distance in seconds, and T_1 the period in the above table. In a large majority of double stars whose orbits have been approximately determined it is certain that the time of revolution is much greater than would result from this rule. It follows that the stars in general are either much less dense, or much more brilliant, than the sun. For reasons that we cannot state here it is likely that the former alternative is more usual than the latter. It is remarkable that, in the case of those bright stars the mass of whose faint companions has been determined, the brilliancy of the latter deviates in the opposite direction; their masses are disproportional to their brightness. Thus the mass of the companion of Sirius is nearly half that of Sirius itself, although the latter gives several thousand times as much light as the companion. The same is probably true of the companion of Procyon, and, in a less degree, of η Cassiopeia. It would seem that in these cases the companion, being of the same age as the bright star, has cooled off more rapidly, and perhaps condensed to a solid or liquid.

The variety of spectra among the stars also emphasizes the diversity of their physical constitution. Sir W. Huggins (*Publications of Sir W. Huggins's Observatory*, vol. i. page 75) shows that the evidence of the spectroscope agrees with the general evolutionary theory. The spectra of the stars may be made to fall into line, so as to form a series, leaving little room for doubt that the actual differences between them represent in the main successive epochs of star life rather than original differences of chemical constitution. When the spectra of close pairs of stars are examined, the difference between the two sets corresponds to the view that the fainter star of the two is in a more advanced stage of condensation.

Distribution of the stars.

The problem of the structure of the heavens, if structure they may be said to have, may be regarded as the ultimate one of sidereal astronomy. Branches of this problem are the questions of the physical constitution of the stars, their possible separation into systems, the stability of those systems, and the duration and stability of the universe itself. The central question around which all the others may be grouped is that of the actual distribution of the stars in space. If we could determine the distance of a star as readily as we do its direction from us, this question would be immediately settled, and a geometric model of the universe could be constructed showing its form and arrangement. But, with the exception of the few stars whose parallax can be measured, the distances of the individual stars are a matter of extremely vague and uncertain inference, and not even the mean distance of any class or group can be settled definitely by any one method of research.

Limit of universe.

It will conduce to clearness in bringing out the bearing of various facts on the problem in question if we state its main point in advance. The most definite form in which it may be considered by the astronomer is this:—As, by increasing the power of our telescopes, we see smaller and smaller stars—are the smallest that are brought into view no more distant than others already known; are they within the sphere of others already observed, or, does every increase of telescopic power bring into view stars farther away? To put the question into another shape—Is the universe of stars limited in extent? Intimately associated with this is the question of the actual distribution in space of the stars which we see with our telescopes. Whether the universe is finite or infinite, it is certain that the portion which we see is of finite extent. Has this visible portion a definite boundary, and, if so, what is the figure of this boundary? The statement of this question may suggest a doubt as to the possibility of answering it. Since the range of vision of our telescopes is necessarily limited, is it not necessarily impossible for us to gather evidence of the finitude of the universe? If with every increase of power we see smaller stars of which we cannot estimate the distance, how can we decide that we are not simply penetrating farther into a mass of infinite extent? An answer to this is reached by the following consideration:—So far as stars of various magnitudes have yet been counted there are about three times as many of each order as of the order next brighter. For example, there are three times as many stars of the 7th magnitude as of the 6th, three times more of the 8th, and so on, to at least the 10th or 11th magnitude, a point beyond which the count is uncertain. An individual star of each order gives about four-tenths the light of one of the next brighter order. It follows that the total amount of light which we receive from all the stars of any one order continually increases as we go to the fainter orders, the greater number of the stars more than compensating for the less amount of light received from each. Consequently, if the stars continued indefinitely so would the total amount of light received from them, and the heavens would be filled with a blaze as bright as the sun. As such is not the case, the series must stop. Where the stopping-point is, we cannot exactly say; but, so far as we can judge from appearances, it can go little farther than the count has thus far extended, except perhaps in the Milky Way. We have therefore every reason to believe that by an increase in the power of our telescopes the number of new stars brought into view would begin to diminish, thus showing the total number to be limited. Hence we conclude that the universe of stars which we study has some bounding limit. The question now is, Can we form any conception of the limit and of the arrangement of the universe within it?

Form of universe.

Direct observation of the apparent distribution of the stars, irrespective of any question of their arrangement, makes one feature of the universe certain. The stars which compose it are not equally numerous in every direction; a large majority lie in or near the zone of the Milky Way. What follows from this fact may be readily seen from Fig. 4, which we conceive to represent a section of the universe by a plane perpendicular to the Milky Way, S being the position of the sun, which, for the moment, we may conceive to be near the centre. What we actually observe is that a very large majority of the stars are contained within the regions ASB and CSD, while the number contained within the larger angles, BSD and ASC, is relatively small. An indefinite number of arrangements, all consistent with this fact, may be conceived; but they are all in some way intermediate between the following:—

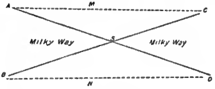


Fig. 4.

I. All, or at least the great mass of, the stars may be contained between two planes, AC and BD, parallel to the Milky Way. We see more stars in the region ASB and CSD, because there is, so to speak, a greater depth of stars there, while toward M and N we see only a comparatively thin stratum. This was the view developed first by the elder Herschel and then by Struve in his *Études d'Astronomie Stellaire.*

II. The actual form of the universe may be spherical, the galaxy being formed by a dense ring of stars around the sphere.

III. The same hypothesis of a universe spherical in general form may be made, but, instead of being a ring, the galaxy is a number of clusters of stars mostly situated near one central plane.

The hypothesis that the boundary of the universe is spherical admits of being tested in a very simple way. Were such the case, the stars would be equally numerous throughout the regions ASC and BSD, the increase in their number beginning only when we reached the boundary of the Milky Way. But all the counts of stars yet made, from the time of Herschel till now, show that the number of stars per square degree continually increases from the two poles of the galaxy to the galaxy itself. Moreover, the rate of increase is as rapid as it would be if the boundary of the universe were two planes parallel to the galactic plane. Unless we make a very improbable hypothesis as to the distribution of the stars around us, this fact must lead us to the conclusion that we actually see to the limits of the universe in all directions away from the galaxy. For, if we did not, the increase in the number of stars in the direction of the galaxy could not be so rapid as it is. It would seem therefore that the first hypothesis of the form of the universe, that of Herschel and Struve, must be at least an approximation to the truth. But that it is not the whole truth will be evident on farther consideration.

We have room only to state in the briefest way the main facts, so far brought to light, on which our conclusion must be based. Beginning with the region immediately around us, what evidence have we of the distribution of the stars, especially of their tendency to condense in the direction of the Milky Way? If we consider that greater brilliancy of the stars implies greater nearness to us, then we should answer this question by considering the relation of the brighter stars to the galaxy. It is a remarkable fact that the condensation towards the galactic zone begins with the brighter stars—we might even say with those of the first magnitude—though we can hardly conceive this to be anything else than the result of accident. From Schiaparelli's maps of the distribution of the stars visible to the naked eye, the position of the Milky Way can be laid down with great exactness. But this does not show that the condensation in the plane of the Milky Way begins with the nearest stars; it only shows that some of the brighter stars are as far as the Milky Way, and emphasizes the extraordinary difference in their absolute brightness.

As we have already said, the proper motions of the stars afford the best index to their distance. Now it is a remarkable and suggestive fact that, when we make a count of the stars of known proper motion in every direction, we find them to be no more numerous in the region of the Milky Way than elsewhere. It appears therefore that the stars which compose the Milky Way are outside the limits within which proper motion has been detected, and that within these limits the stars are distributed with a fair approach to uniformity. A careful look at the Milky Way, especially the region south of Aquila, will suffice to show that it suggests agglomerations of stars rather than a continuous zone in which there is a uniform distribution of the stars. Moreover, it seems that our system is nearer to this part of the Milky Way than to the opposite; in other words, we are not centrally situated. It is a remarkable fact that in the intervals between the brighter portions of the Milky Way, about 17 hours of right ascension and between 20° and 22° of south declination, we have regions several degrees square where the stars are comparatively few in number. This is in general true of the openings in this region. We conclude from this that in the latter we have a phenomenon distinct from that of merely increased star density arising from greater depth. Our general conclusions as to the structure of the universe may be summed up in these four propositions:—

1. The general form of the universe of stars to which our sun belongs is that of a flattened cylinder, or extreme oblate spheroid, as was supposed by Herschel and Struve.

2. The phenomenon of the Milky Way is not due alone to the fact that we see more stars in the equatorial regions of this spheroid, but to the fact that this region is occupied through its entire extent by a series of agglomerations of stars, within which space is richer in stars than in the interior where we are situated.

3. Our sun is situated near the central plane of the spheroid, but eccentrically so as to be nearer the boundary in a direction of perhaps 18 hours in right ascension, between the equator and 50° of south declination.

4. It is possible, but not yet certain, that we are so near the galactic stars in this region that we may soon be enabled to discover a proper motion among them.

(s. n.)

Astropalia, classical *Astypalæa*, an island with good harbours, in the south part of the Ægean, situated in 36·5° N. lat. and immediately west of 26·5° E. long. The Roman emperors recognized it as a free state; and in the Middle Ages it was called *Stampalia*, and belonged to the noble Venetian family of Quirini. It was taken by the Turks in the 16th century, and is now noted for its sponges. The customs and dress of the people, who speak a patois of romaic origin, are interesting.

Asua, R. See Nile.

Asunción, or **La Asunción,** capital of the Paraguay Republic, is situated on the left bank of the Paraguay river, in 25° 16′ 04″ S. lat. and 57° 42′ 40″ W. long. The population in 1887 was 24,838, but it now exceeds 47,000. Railway communication has been established with Pirapó, and the town is rapidly becoming modernized. It is served by a tramway, has its principal streets lighted by electricity, and is well supplied with telephones. There are a National College, attended by over two hundred students, a public library, and, in the neighbourhood, an agricultural school with a model farm. Near the town, too, are several breweries, tanneries, flour mills, and factories for matches, soap, bricks, earthenware, palm-leaf hats, etc. In 1890 the imports were valued at $2,725,611 (gold), in 1899 at $2,147,838; exports were valued at $2,901,589 in 1890 and $2,021,023 in 1899. Both imports end exports fluctuate considerably in value. In 1898 in the foreign trade only 418 vessels (mostly "liners") entered, and 408 cleared.

Atbara, R. See Abyssinia.

Atchison, the capital of Atchison county, Kansas, U.S.A., in 39° 34′ N. lat. and 95° 8′ W. long., on the west bank of the Missouri. The river is navigable at this point. The elevation on the river bank is 795 feet, most of the city being situated at a higher level. The city is divided into five wards, is regularly laid out, supplied with water by pumping from Missouri river, and is well drained. It is entered by four great railways, the Atchison, Topeka and Santa Fé, the Chicago, Burlington and Quincy, the Chicago, Rock Island and Pacific, and the Missouri Pacific. It is the site of Midland and St Benedict colleges. Founded in 1854, it at once grew rapidly, and four years later it received a city charter. Population (1880), 15,105; (1890), 13,963; (1900), 15,722.

Ath, a town of Belgium, in the province of Hainaut, on the river Dender, about 30 miles by rail from Brussels. The tower of the church of Saint-Julien now lacks the high spire for which it was noted, and the ancient Tour du Burbant has become ruinous. Population (communal) (1880), 9301; (1890), 9868; (1897), 10,646.

Athabasca (*Athapescow* or *Elk*), a river of Alberta and Athabasca districts, Canada, rises in the Rocky Mountains in 52° 10′ N. lat. and 117° 10′ W. long., and flows in a north-easterly direction into the lake of the same name. It is 740 miles long and has a number of important tributaries, including the M'Leod, Pembina, Lesser Slave, and Clearwater. *Athabasca Lake* is 195 miles long, W. to E., from 20 to 32 miles wide, has an area of 3085 square miles, and is at an altitude of 690 feet above the sea. Shallow-draught steamers navigate the lake and river and Lesser Slave Lake and River with one interruption—at Grand Rapids near the mouth of the Clearwater river.

For Athabasca district see North-West Territories.

Athenry, an inland town in the county of Galway, Ireland, 14 miles E. of Galway, on the Midland Great Western Railway. The old Dominican monastery was extensively repaired by the Board of Works in 1893. Population, 910.

ATHENS.

I.—Ancient Athens.

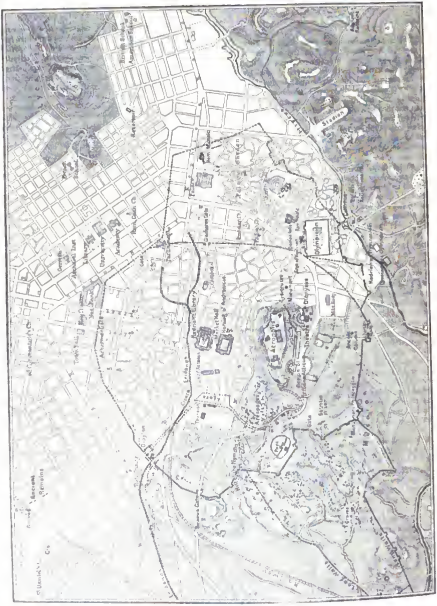
Recent investigation on scientific lines has thrown a new and unexpected light on the art, the monuments, and the topography of ancient Athens. Numerous and costly excavations have been carried out by the Greek Government and by native and foreign scientific societies, while accidental discoveries have been frequently made during the building of the modern town. The museums, enriched by a constant inflow of works of art and inscriptions, have been carefully and scientifically arranged, and afford opportunities for systematic study denied to scholars of the past generation. Improved means of communication have enabled many acute observers to apply the test of scrutiny on the spot to theories and conclusions mainly based on literary evidence; five foreign schools of archæology, directed by eminent scholars, lend valuable aid to students of all nationalities, and lectures are frequently delivered in the museums and on the more interesting and important sites. The native archæologists of the present day hold a recognized position in the scientific world; the patriotic sentiment of former times, which prompted their zeal but occasionally warped their judgment, has been merged in devotion to science for its own sake, and the supervision of excavations, as well as the control of the art-collections, is now in highly competent hands. Athens has thus become a centre of learning, a meeting-place for scholars, and a basis for research in every part of the Greek world. The attention of many students has naturally been concentrated on the ancient city, the birthplace of European art and literature, and a great development of investigation and discussion in the special domain of Athenian archæology has given rise to a voluminous literature. Many theories hitherto universally accepted have been called in question or proved to be unsound: the views of Leake, for instance, have been challenged on various points, though many of the conclusions of that great topographer have been justified and confirmed by modern research. The supreme importance of a study of Greek antiquities on the spot, long understood by scholars on the Continent and in America, is gradually coming to be recognized in England, where a close attention to ancient texts, not always adequately supplemented by a course of local study and observation, has hitherto fostered a peculiarly conservative attitude in regard to the problems of Greek archæology. Since the foundation of the German Institute in 1874, Athenian topography has to a large extent become a speciality of German scholars, among whom Wilhelm Dörpfeld occupies a pre-eminent position owing to his great architectural attainments and unrivalled local knowledge. Many of his bold and novel theories have provoked strenuous opposition, while others have met with general acceptance, except among scholars of the more old-fashioned type.

The early citadel.

Prehistoric Athens.—Numerous traces of the "Mycenæan" epoch have recently been brought to light in Athens and its neighbourhood. Among the monuments of this age discovered in the surrounding districts are the rock-hewn tombs of Spata, accidentally revealed by a landslip in 1877, and the domed sepulchre at Menidi, near the ancient Acharnæ, excavated by Lolling in 1879. Other "Mycenæan" landmarks have been laid bare at Eleusis, Thoricus, Halæ, and Aphidna. These structures, however, are of comparatively minor importance in point of dimensions and decoration; they were apparently designed as places of sepulture for local chieftains, whose domains were afterwards incorporated in the Athenian realm by the συνοικισμὸς attributed to Theseus. The situation of the Acropolis, dominating the surrounding plain and possessing easy communication with the sea, favoured the formation of a relatively powerful state — inferior, however, to Tiryns and Mycenæ; the myths of Cecrops, Erechtheus, and Theseus bear witness to the might of the princes who ruled in the Athenian citadel, and here we may naturally expect to find traces of massive fortifications resembling in some degree those of the great Argolid cities. Such, in fact, have been brought to light by the recent excavations on the Acropolis (1885-1889). Remains of primitive polygonal walls which undoubtedly surrounded the entire area have been found at various points a little within the circuit of the existing parapet. The best preserved portions are at the eastern extremity, at the northern side near the ancient "royal" exit, and at the south-western angle. The course of the walls can be traced with a few interruptions along the southern side. On the northern side are the foundations of a primitive tower and other remains, apparently of dwelling-houses, one of which may have been the πυκινὸς δόμος Ἐρεχθῆος mentioned by Homer (*Od.* vii. 81). Among the foundations were discovered fragments of "Mycenæan" pottery. The various approaches to the citadel on the northern side—the rock-cut flight of steps north-east of the Erechtheion, the stairs leading to the well Clepsydra, and the intermediate passage supposed to have furnished access to the Persians—are all to be attributed to the primitive epoch. Two pieces of polygonal wall, one beneath the bastion of Nike Apteros, the other in a direct line between the Roman gateway and the door of the Propylæa, are all that remain of the primitive defences of the main entrance.

The Pelasgicum.

These early fortifications of the Acropolis, ascribed to the primitive non-Hellenic Pelasgi, must be distinguished from the Pelasgicum or Pelargicum, which was in all probability an encircling wall, built round the base of the citadel and furnished with nine gates from which it derived the name of Enneapylon. Such a wall would be required to protect the clusters of dwellings around the Acropolis as well as the springs issuing from the rock, while the gates opening in various directions would give access to the surrounding pastures and gardens. This view, which is that of Curtius, alone harmonizes with the statement of Herodotus (vi. 137) that the wall was "around" (περί) the Acropolis and that of Thucydides (ii. 17) that it was "beneath" (ὑπό) the fortress. Thus it would appear that the citadel had an outer and an inner line of defence in pre-historic times. The space enclosed by the outer wall was left unoccupied after the Persian wars in deference to an oracular response apparently dictated by military considerations, the maintenance of an open zone being desirable for the defence of the citadel. A portion of the outer wall has been recognized in a piece of primitive masonry discovered near the Odeion of Herodes Atticus; other traces will probably come to light when the northern and eastern slopes of the Acropolis have been completely explored. Leake, whom Frazer follows, assumed the Pelasgicum to be a fortified space at the western end of the Acropolis; this view necessitates the assumption that the nine gates were built one within the other, but early antiquity furnishes no instance of such a construction; Dörpfeld believes it to have extended from the grotto of Pan to the sacred precinct of Asclepius. The well-known passage of Lucian (*Piscator* 47) cannot be regarded as decisive for any of the theories advanced, as any portion of the old *enceinte* dismantled by the Persians may have retained the name in later times.



PLAN OF ATHENS AND ENVIRONS.

The Pnyx.

To the Pelasgic era may also be referred (with Curtius and Milchhöfer) the terraces of the Pnyx with the wall of massive masonry supporting the lower platform: the theory of these scholars, however, that the whole precinct was a sanctuary of the

Pelasgian Zeus cannot be regarded as proved, nor is it easy to abandon the generally received view that this was the scene of the popular assemblies of later times, notwithstanding the apparent unsuitability of the ground and insufficiency of room for a large multitude. These difficulties are met by the assumption that the Cyclopean retaining-wall rose to a considerable height, supporting a theatre-like structure capable of seating many thousand persons. The pre-historic rock-dwellings in this neighbourhood (the quarter of Melite) have been found to extend to a considerable distance towards the S.E. in the direction of Phaleron.

The Hellenic Period.—While modern research has added considerably to our knowledge of pre-historic Athens, a still greater light has been thrown on the architecture and topography of the city in the earlier historic or "archaic" era, the subsequent age of Athenian greatness, and the period of decadence which set in with the Macedonian conquest. We must here group these important epochs together, as distinguished from the later period of Roman rule, and confine ourselves to a chronological record of the principal discoveries by which they have been illustrated in recent years.

Progress of research 1870-74.

The Dipylon.

In 1870, the Greek Archæological Society undertook a series of excavations in the Outer Cerameicus which had already been partially explored by various scholars. The operations, which were carried on at intervals till 1890, resulted in the discovery of the Dipylon Gate, the principal entrance of ancient Athens. The Dipylon consists of an outer and an inner gate separated by an oblong courtyard and flanked on each side by towers; the gates were themselves double, being each composed of two apertures intended for the incoming and outgoing traffic. An opening in the city wall a little to the south-west, supposed to have been the Sacred Gate (*ἱερὰ πύλη*), was in all probability an outlet for the waters of the Eridanus. This stream, which has hitherto been regarded as the eastern branch of the Ilissus rising at Kæsariane, has been identified by Dörpfeld with a brook descending from the southern slope of Lycabettus and conducted in an artificial channel to the north-western end of the city, where it made its exit through the walls, eventually joining the Ilissus. The channel was open in Greek times, but was afterwards covered by Roman arches; it appears to have served as the main drain of the city. Between this outlet and the Dipylon were found a boundary-stone, inscribed *ὅρος Κεραμεικοῦ*, which remains in its place, and the foundations of a large rectangular building, possibly the Pompeion, which may have been a robing-room for the processions which passed this way. On both sides of the Dipylon the walls of Themistocles, faced on the outside by a later wall, have been traced for a considerable distance. The excavation of the outlying cemetery revealed the unique "Street of the Tombs" and brought to light a great number of sepulchral monuments, many of which remain *in situ*. Especially noteworthy are the *stelæ* or reliefs representing scenes of leave-taking, which, though often of simple workmanship, are characterized by a touching dignity and restraint of feeling. In this neighbourhood were found a great number of 7th century tombs containing pottery with geometric designs. A considerable portion of the district remains unexplored.

The Dionysiac theatre.

Within the same period was carried out the complete excavation of the Dionysiac theatre. The site, which had been accurately determined by Leake, was explored by Strack in 1862, and the researches subsequently undertaken by the Greek Archæological Society were concluded in 1879. It was not, however, till 1886 that traces of the original Greek orchestra were pointed out by Dörpfeld. The arrangements of the stage and orchestra as we now see them belong to Roman times; the *cavea* or auditorium dates from the administration of the orator Lycurgus (337-323 B.C.), and nothing is left of the theatre in which the plays of Æschylus and Sophocles were acted, save a few small remnants of polygonal masonry. These, however, are sufficient to mark out the circuit of the ancient orchestra, on which the subsequently-built proscenia encroached. The oldest stage-building was erected in the time of Lycurgus; it consisted of a rectangular hall with square projections (*παρασκήνια*) on each side; in front of this was built in late Greek or early Roman times a stage with a row of columns which intruded upon the orchestra space; a later and larger stage, dating from the time of Nero, advanced still further into the orchestra, and this was finally faced (probably in the 3rd century A.D.) by the "bema" of Phædrus, a platform-wall decorated with earlier reliefs, the slabs of which were cut down to suit their new position. The remains of two temples of Dionysus have been found adjoining the stoa of the theatre, and an altar of the same god adorned with masks and festoons: the smaller and earlier temple probably dates from the 6th century B.C., the larger from the end of the 5th or the beginning of the 4th century.

The Asclepieion.

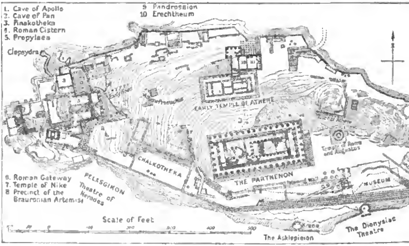
Immediately west of the theatre of Dionysus is the sacred precinct of Asclepius, which was excavated by the Archæological Society in 1876-78. Here were discovered the foundations of the celebrated Asclepieion, together with several inscriptions and a great number of votive reliefs offered by grateful invalids and valetudinarians to the god of healing. Many of the reliefs belong to the best period of Greek art. A Doric colonnade with a double row of columns was found to have extended along the base of the Acropolis for a distance of 54 yards; behind it in a chamber hewn in the rock is the sacred well mentioned by Pausanias. The colonnade was a place of resort for the patients; a large building close beneath the rock was probably the abode of the priests.

Complete excavation of the Acropolis, 1885-88.

The great excavations on the Acropolis, begun in November 1885 and completed in December 1888, rank among the most surprising achievements of modern research. The results of these operations, which were conducted by the Archæological Society under the direction of Kavvadias and Kawerau, must be summarized with the utmost brevity. The great deposits of sculpture and pottery now unearthed, representing all that escaped from the ravages of the Persians and the burning of the ancient shrines, afford a startling revelation of the development of Greek art in the 7th and 6th centuries. Numbers of statues—among them a series of draped and richly-coloured female figures — masterpieces of painted pottery, only equalled by the Attic vases found in Magna Græcia and Etruria, and numerous bronzes, were among the treasures of art now brought to light. All belong to the "archaic" epoch; only a few remains of the greater age were found, including some fragments of sculptures from the Parthenon and Erechtheion. Among the inscriptions now discovered was a record of the gold and ivory bought for the great statue of Athena Parthenos, which enables us to determine the ratio of silver to gold in the age of Phidias. We are principally concerned, however, with the results which add to our knowledge of the topography and architecture of the Acropolis. The entire area of the summit was now thoroughly explored, the excavations being carried down to the surface of the rock, which on the southern side was found to slope outwards to a depth of 14 metres. In the lower strata were discovered the remnants of Cyclopean or pre-historic architecture already mentioned.

The Parthenon.

The foundations of the Parthenon were now for the first time completely investigated, as well as the area of the interior. The huge substruction, probably built under Cimon's administration soon after the Persian war, is 250 feet long by 105 feet broad; it was designed for a longer and somewhat narrower building than the Parthenon, the stylobate of which measures 228 feet by 101. This earlier or Cimonian temple, which was never finished, was of Pentelic marble, with eight columns at the ends and nineteen at the sides; only some of the lower drums, which are unfluted, have been found, and there is nothing to show that an upper portion ever existed. With regard to the interior of the Parthenon much controversy exists; the western compartment, which corresponds to the opisthodomos in other temples, appears to have been the Παρθενών proper or "maiden's chamber," and like the eastern compartment, or "Hekatompedon," to have given its name to the whole building; the arrangement and interpretation of the sculptures have also been a fertile theme for discussion. For details regarding the Parthenon and the older temple the special authorities enumerated in the bibliography should be consulted. In the deep interval between the substruction and the south wall of the Acropolis ran a long retaining-wall constructed for temporary use during the building of the temple. The lower portion of the substruction is believed by Penrose to have been the foundation of the ancient "Hekatompedon" destroyed by the Persians. The name was subsequently applied to the cella or eastern chamber of the Parthenon, which is exactly 100 feet long, and also became a popular designation of the temple itself.



Plan of the Acropolis, Athens. (*By permission of the Hellenic Society.*)

▨ Cyclopean Masonry.

The old temple of Athena.

The ancient Hekatompedon, however, may in all probability be identified with an early temple, also 100 feet long, the foundations of which were pointed out in 1885 by Dorpfeld on the ground immediately adjoining the south side of the Erechtheion. On this spot was apparently the primitive sanctuary of Athena, the rich temple (πίων νηός) of Homer, in which the cult of the goddess was associated with that of Erechtheus (*Il.* ii. 549); the Homeric temple is identified by Fürtwangler with the "compact house of Erechtheus" (*Od.* vii. 81), which, he holds, was not a royal palace but a place of worship, and traces of it may perhaps be recognized in the fragments of prehistoric masonry enclosed by the existing foundations. The foundations seem to belong to the 7th century, except those of the colonnade, which was added possibly by Pisistratus. According to Dorpfeld, this was the "old temple" of Athena Polias, frequently mentioned in literature and inscriptions, in which was housed the most holy image or ξόανον of the goddess which fell from heaven; it was burnt, but not completely destroyed, during the Persian war, and some of its external decorations were afterwards built into the north wall of the Acropolis; it was subsequently restored, he thinks, with or without its colonnade—in the former case a portion of the peristyle must have been removed when the Erechtheion was built so as to make room for the porch of the maidens; the building was set on fire in 406 B.C. (Xen. *Hell.* i. 6. 1), and the conflagration is identical with that mentioned by Demosthenes (*In Timocr.* xxiv. 155); its opisthodomos served as the Athenian treasury in the fifth and fourth centuries; the temple is the ἀρχαῖος νεὼς τῆς Πολιάδος mentioned by Strabo (ix. 16), and it was still standing in the time of Pausanias, who applies to it the same name (i. 27. 3). The conclusion that the foundations are those of an old temple burnt by the Persians has been generally accepted, but other portions of Dorpfeld's theory—more especially his assumption that the temple was restored after the Persian war—have provoked much controversy. Thus J. G. Frazer maintains the hitherto current theory that the earliest temple of Athena and Erechtheus was on the site of the Erechtheion; that the Erechtheion inherited the name ἀρχαῖος νεώς from its predecessor, and that the "opisthodomos" in which the treasures were kept was the west chamber of the Parthenon; Fürtwangler and Milchhöfer hold the strange view that the "opisthodomos" was a separate building at the east end of the Acropolis, while Penrose thinks the building discovered by Dörpfeld was possibly the Cecropeion. Curtius and J. W. White, on the other hand, accept Dörpfeld's identification, but believe that only the western portion of the temple, or opisthodomos, was rebuilt after the Persian war. Admitting the identification, we may perhaps conclude that the temple was repaired in order to provide a temporary home for the venerated image and other sacred objects: no traces of a restoration exist, but the walls probably remained standing after the Persian conflagration. The removal of the ancient temple was undoubtedly intended when the Erechtheion was built, but superstition and popular feeling may have prevented its demolition and the removal of the ξόανον to the new edifice. The temple consisted of an eastern cella with pronaos; behind this was the opisthodomos, divided into three chambers—possibly treasuries—with a portico at the western end. The peristyle, if we compare the measurements of the stylobate with those of the drums built into the wall of the Acropolis, may be concluded to have consisted of six columns at the ends and twelve at the sides.

The Erechtheion.

The internal arrangements of the Erechtheion are still a subject of controversy. The peculiar design of the temple is attributable to the necessity imposed on the architect of including within the building a number of sacred places, and combining several cults. Within its precincts Pausanias (i. 26. 5) found altars to Poseidon, with whose worship that of Erechtheus was associated, to the hero Butes and to Hephæstus, also a well of salt water and the imprint of Poseidon's trident. Whether he also found here the ancient image of Athena and her ever-burning lamp is open to doubt owing to the vagueness of his language; he may mean to attribute these objects either to the Erechtheion or to the old temple adjoining it. If he places them in the Erechtheion that name can strictly apply to only a portion of the existing building, the remainder of the temple, which he describes as "double," being the "sanctuary of Athena" (ναὸς τῆς Πολιάδος) which he subsequently mentions. On this assumption the eastern and larger chamber of the Erechtheion has generally been identified with the shrine of Athena Polias. The western chamber adjoining the porch of the Maidens may possibly have contained the tomb of Cecrops, and the altars mentioned by Pausanias; the identification of the rock-hewn cistern beneath the pavement in this compartment with the salt well of Erechtheus is very doubtful. The mark of the trident is in the crypt beneath the north portico. The beautiful north door of the temple is held by E. Gardner and R. Schultz (*Journal Hell. Stud.* 1891) not to be identical with the original one, the present heavy door-jambs and the lintel being restorations.

The Pandroseion and Chalcotheke.

The excavation of the Pandroseion or temenos of Pandrosos, the daughter of Cecrops, which adjoins the Erechtheion on the west, has revealed no traces of a temple. The site of this precinct, in which the sacred olive tree of Athena grew, has been almost certainly fixed by an inscription found in the bastion of Odysseus. At its north-western extremity is a platform of levelled rock which may have supported the altar of Zeus Hypsistus. The excavation of the ground immediately west of the Parthenon brought to light the remains of a large rectangular building, apparently fronted by a colonnade. This has been identified with the Chalcotheke, a storehouse of bronze implements and arms, which was formerly supposed to lie against the north wall near the Propylæa. The site was hitherto erroneously believed to be the temenos of Athena Ergane. The adjoining temple of Nike is proved by an inscription found in 1896 to have been built before the Propylæa.

Removal of historic monuments.

During the course of the excavations on the Acropolis the bastion built by the Greek chieftain Odysseus, to protect the staircase leading down to the well Clepsydra below the north-western cliff, was demolished. The "Tower of the Franks," an interesting remnant of the Middle Ages which stood near the temple of Nike, had been taken down in 1874, despite the protests of Freeman, Penrose, and other scholars. The projected removal of the Turkish minaret in the south-west corner of the Parthenon has happily not been carried out; its preservation is essential to the stability of the adjoining masonry.

Excavations in 1892-98.

In 1892 Dörpfeld began a series of excavations in the district between the Acropolis and the Pnyx with the object of determining the situation of the buildings described by Pausanias as existing in the neighbourhood of the Agora, and more especially the position of the Enneacrunus fountain. The Enneacrunus has hitherto been generally identified with the spring Callirrhoe in the bed of the Ilissus, a little to the south-east of the Olympieion; it is apparently placed by Thucydides (ii. 15) in proximity to that building, as well as the temple of Dionysus ἐν λίμναις and other shrines which he mentions as situated to the south of the Acropolis. On the other hand Pausanias (i. 14. 1), who never deviates without reason from the topographical order of his narrative, mentions the Enneacrunus in the midst of his description of certain buildings which were undoubtedly in the region of the Agora, and unless he is guilty of an unaccountable digression the Enneacrunus which he saw must have lain west of the Acropolis. It is now generally agreed that the Agora of classical times covered the low ground between the hill of the "Theseion," the Areopagus, and the Pnyx; and Pausanias, in the course of his description, appears to have reached its southern end. The excavations revealed a main road of surprisingly narrow dimensions winding up from the Agora to the Acropolis. A little to the south-west of the point where the road turns towards the Propylæa was found a large rock-cut cistern or reservoir which Dörpfeld identifies with the Enneacrunus. The reservoir is supplied by a conduit of 6th-century tiles connected with an early stone aqueduct, the course of which is traceable beneath the Dionysiac theatre and the royal garden in the direction of the upper Ilissus. These elaborate waterworks were, according to Dörpfeld, constructed by the Pisistratids in order to increase the supply from the ancient spring Callirrhoe; the fountain was furnished with nine jets, and henceforth known as Enneacrunus. This identification has been hotly contested by many scholars, and the question must still be regarded as undecided. An interesting confirmation of Dörpfeld's view is furnished by the map of Guillet and Coronelli, published in 1672, in which the Enneacrunus is depicted as a well with a stream of running water in the neighbourhood of the Pnyx. The fact that spring water is not now found in this locality is by no means fatal to the theory: recent engineering investigations have shown that much of the surface water of the Attic plain has sunk to a lower level. In front of the reservoir is a small open space towards which several roads converge; close by is a triangular enclosure of polygonal masonry, in which were found various relics relating to the worship of Dionysus, a very ancient wine-press (ληνός), and the remains of a small temple. Built over this early precinct, which Dörpfeld identifies with the Dionyseion ἐν λίμναις, or Lenæon, is a basilica-shaped building of the Roman period, apparently sacred to Bacchus: in this was found an inscription containing the rules of the society of the Iobacchi. There is an obvious difficulty in assuming that λίμναι, in the sense of "marshes," existed in this confined area, but stagnant pools may still be seen here in winter. Another enclosure, a little to the south, is proved by an inscription to have been a sanctuary of the hitherto unknown hero Amynus with whose cult those of Asclepius and the hero Dexion were here associated; under the name Dexion, the poet Sophocles is said to have been worshipped after his death. The whole district adjoining the Areopagus was found to have been thickly built over. The remains of the Stoa Basileios, in which the Archon Basileus held his court and the Areopagus Council sat, were perhaps brought to light in the winter of 1897-98, when the excavations were extended to the eastern slope of the "Theseion" hill. Here was found a rectangular structure resembling a temple, but with a side door to the north: it possessed a portico of six columns. The north slope of the Areopagus, where a number of early tombs were found, was also explored, and the limits of the Agora on the south and north-west were approximately ascertained. A portion of the main road leading from the Dipylon to the Agora was discovered.

The Grottoes of Pan and Apollo

In 1896 excavations with the object of exploring the whole northern and eastern slopes of the Acropolis were begun by Kavvadias. The pathway between the citadel and the Areopagus was found to be so narrow that it is certain the Panathenaic procession cannot have taken this route to the Acropolis. On the north-west rock the caves known as the grottoes of Pan and Apollo were cleared out: these consist of a slight high-arched indentation immediately to the east of the Clepsydra and a double and somewhat deeper cavern a little farther to the east. In the first mentioned are a number of niches in which *πίνακες* or votive tablets were placed: some of these offerings, inscribed with dedications to Apollo, have been discovered. The whole locality was the seat of the ancient cult of this deity, afterwards styled "Hypakraeos," with which was associated the legend of Creusa and the birth of Ion. The worship of Pan was introduced after the Persian wars, in consequence of an apparition seen by Pheidippides, the Athenian courier, in the mountains of Arcadia. Another cave more to the west was revealed by the demolition of the bastion of Odysseus. To the east a much deeper and hitherto unknown cavern has been revealed, which Kavvadias identifies with the grotto of Pan. Close to it are a series of steps hewn in the rock which connect with those discovered in 1886 within the Acropolis wall. Farther east is an underground passage leading eastwards to a cave supposed to be the sanctuary of Aglaurus; with this passage is connected a secret staircase leading up through a cleft in the rock to the precinct of the Errephori on the Acropolis. It is conceivable that the priestesses employed this exit when descending on their mysterious errand.

The Cynosarges and gymnasium of Hadrian.

The Cynosarges, from earliest times a sanctuary of Heracles, later a celebrated gymnasium and the school of Antisthenes the Cynic, has hitherto been generally supposed to have occupied the site of the Monastery of the Angels (Asomati) on the eastern slope of Lycabettus; its situation, however, has been fixed by Dorpfeld at a point a little to the south of the Olympieion, on the left bank of the Ilissus. Here a series of excavations, carried out by the British School in 1896-97 under the direction of Cecil Smith, revealed the foundations of an extensive Greek building, the outlines of which correspond with those of a gymnasium; it possessed a large bath or cistern, and was flanked on two sides by water-courses. An Ionic capital found here possibly belonged to the palæstra. The identification, however, cannot be regarded as certain in the absence of inscriptions. To the north-east were found the remains of a very large rectangular structure of the Roman epoch, bearing a striking resemblance in design and construction to the "Stoa," or Library of Hadrian, situated to the north of the Acropolis: this may in all probability be identified with the Gymnasium of Hadrian, the position of which was hitherto entirely unknown.

The Roman Period.—The most important achievement of recent research with regard to the Roman period has been the uncovering of the new or Roman Agora. In 1890 and 1891 the ground immediately to the west of the "Tower of the Winds" was excavated by the Archæological Society, and though the operations have been interrupted, owing to the difficulty of expropriating the neighbouring owners, the dimensions of the Agora have been practically ascertained. It consisted of an open square surrounded by an Ionic colonnade, into which opened a number of shops or storehouses. The eastern gate was adorned with four Ionic columns on the outside and two on the inside, the western entrance being the well-known portico of Athena Archegetis. The whole conclave may be compared with the enclosed bazaars or khans of Oriental cities, which are usually locked at night. Immediately to the north of the new Agora is a vast rectangular building of Roman date, the eastern side of which was explored in 1885-86. A portion of its western front, adorned with monolith unfluted Corinthian columns, is still standing—the familiar "Stoa" of Hadrian; another well-preserved portion, with six pilasters, runs parallel to the west side of Æolus Street. The interior consisted of a spacious court surrounded by a colonnade of 100 columns, into which five chambers opened at the eastern end. A portico of four fluted Corinthian columns on the western side formed the entrance to the quadrangle. This cloistered edifice may be identified with the library of Hadrian mentioned by Pausanias; the gymnasium, which he tells us also possessed 100 columns, being probably the building discovered by the British School near the Ilissus: the books were, perhaps, stored in a square building which occupied a portion of the central area. In 1883 the substructure of the gigantic Olympieion was excavated by Penrose, who proved the correctness of Dorpfeld's theory that the building was octostyle; it possessed 104 Corinthian columns, of which 48 stood in triple rows under the pediments, and 56 in double rows at the sides. Fragments of Doric columns and foundations were discovered, probably belonging to the temple begun by Pisistratus, the orientation of which differed slightly from that of the later structure. In 1898 the peribolos of the temple was excavated without important results: it is to be hoped that the stability of the columns has not been affected by the operations. Numerous Roman mosaics and other remains had already been found in the adjoining public garden over which the "city of Hadrian" extended. Excavations round the monument of Philopappus on the Museion Hill showed that the structure was nearly square, the curved front still remaining being only a portion of the building. On the Acropolis the foundations of the little circular temple of Rome and Augustus were laid bare during the excavations of 1885-88: the temple was of white marble, and had a peristyle of nine Ionic columns. An inscription in bronze letters, attached in A.D. 61 to the eastern architrave of the Parthenon, has been successfully recovered by E. Andrews of the American school. The letters and the nails by which they were fastened have disappeared, but an accurate observation of the nail-marks enabled the shapes of the letters to be determined. The inscription apparently records the erection of some monument by the Athenians in honour of the emperor Nero.

State of the Parthenon.

The Parthenon escaped without serious injury from the earthquakes of 1894. A piece of one of the drums of a column on the north side fell to the ground and a portion of one of the blocks in the architrave of the opisthodomos. These injuries, however, fortunately attracted attention to the condition of the building. A committee composed of Greek and foreign architects was appointed to superintend the necessary repairs, and the opinion of three distinguished authorities, Joseph Durm, L. Magne, and F. C. Penrose, was invited. It was wisely decided to abstain from any attempt at restoration and only to employ new material when necessary for the preservation of the existing remains. The repairs were begun in 1896 under the supervision of the Greek architect Balanos. It was found that several of the blocks in the architrave of the opisthodomos were in a very defective condition, probably owing to the action of fire at some past time. One of these, which supported two slabs of the Panathenaic frieze, has been replaced by new marble, and the delicate operation of removing and readjusting the sculptured slabs has been successfully carried out. Others of the blocks have been carefully pieced as well as some of the capitals of the inner row of columns. The broken lintel of the great western door will be replaced with a large new stone, and the brick masonry which encumbers the doorway will be removed. The operations, which were interrupted by the war of 1897, will probably extend over several years. It is proposed to clean out the crevices in the upper parts of the building and to fill them with cement or lead, special care being taken to prevent the percolation of rain water. The Panathenaic frieze has already suffered considerably from exposure to the weather. As the proposal to remove the sculptures to a museum and to replace them by casts will hardly be entertained, steps should be taken to protect them against rain and also to render them accessible to close inspection.

II. MODERN ATHENS.

The Modern City.

At the conclusion of the War of Independence, Athens was little more than a village of the Turkish type, the poorly-built houses clustering on the northern and eastern slopes of the Acropolis. The narrow crooked lanes of this quarter still contrast with the straight, regularly laid out streets of the modern city, which extends to the north-west, north, and east of the ancient citadel. The greater commercial advantages offered by Nauplia, Corinth, and Patras were outweighed by the historic claims of Athens in the choice of a capital for the newly-founded kingdom, and the seat of government was transferred hither from Nauplia in 1834. The new town was, for the most part, laid out by the German architect Schaubert. It contains several squares and boulevards, a large public garden, and many handsome public and private edifices. A great number of the public institutions owe their origin to the munificence of patriotic Greeks, among whom Andreas Syngros and George Averoff may be especially mentioned. The royal palace, designed by Gartner, is a tasteless structure; attached to it is a beautiful garden laid out by Queen Amalia, which contains a well-preserved mosaic floor of the Roman period: the grounds, together with the adjoining public garden, lie within the boundaries of the ancient Hadrianopolis, or *Novæ Athenæ*. On the S.E. is the newly-built palace of the Crown Prince. The Academy, from designs by Hansen, is constructed of Pentelic marble in the Ionic style: the colonnades and pediments are richly coloured and gilded, and may perhaps convey some idea of the ancient style of decoration. Close by is the University, with a colonnade adorned with paintings, and the Vallianean Library with a handsome Doric portico of Pentelic marble. The Observatory, which is connected with the university, stands on the summit of the Hill of the Nymphs; like the Academy, it was erected at the expense of a wealthy Greek, Baron Sina of Vienna. In the public garden is the Zappeion, a large building with a Corinthian portico, intended for the display of Greek industries; here also is a monument to Byron, erected in 1896. The Boulé, or parliament-house, possesses a considerable library. Other public buildings are the Polytechnic Institute, built by contributions from Greeks of Epirus, the theatre, the Arsakeion (a school for girls), the Varvakeion (a gymnasium or boys' school), the military school (*σχολὴ εὐελπίδων*), and several hospitals and orphanages. The Cathedral, a large modern structure, is devoid of architectural merit, but some of the smaller, ancient, Byzantine churches are singularly interesting and beautiful. Among the private residences, the mansion built by Dr. Schliemann, the discoverer of Troy, is the most noteworthy; its decorations are in the Pompeian style.

Museums.

The museums of Athens are daily growing in importance with the progress of excavation. They are admirably arranged, and the remnants of ancient art which they contain have fortunately escaped injudicious restoration. The National Museum, erected in 1866, is especially rich in archaic sculptures and in sepulchral and votive reliefs. A copy of the Diadumenos of Polycleitus from Delos and temple-sculptures from Epidaurus, and the Argive Heræon are among the more notable of its recent acquisitions. It also possesses the famous collection of prehistoric antiquities found by Schliemann at Tiryns and Mycenæ, other "Mycenæan" objects discovered at Nauplia and in Attica, as well as the still earlier remains excavated by Tsountas in the Cyclades and by the British School at Phylakope in Melos; terra-cottas from Tanagra and Asia Minor; bronzes from Olympia, Delphi, and elsewhere, and numerous painted vases, among them the unequalled white *lekythoi* from Athens and Eretria. The Epigraphical Museum contains an immense number of inscriptions arranged by H. G. Lolling and A. Wilhelm of the Austrian Institute. The Acropolis Museum (opened 1878) possesses a singularly interesting collection of sculptures belonging to the "archaic" period of Greek art, all found on the Acropolis; here, too, are some fragments of the pedimental statues of the Parthenon and several reliefs from its frieze, as well as the slabs from the balustrade of the temple of Nike. The Polytechnic Institute contains a museum of interesting objects connected with modern Greek life and history. In the Academy is a valuable collection of coins superintended by Svoronos. Of the private collections those of Schliemann and Karapanos are the most interesting: the latter contains works of art and other objects from Dodona. There is a small museum of antiquities at the Piræus. A museum of casts of the Greek masterpieces in foreign collections is much needed for the purposes of comparative study.

Scientific Institutions.

Owing to the numbers and activity of its institutions, both native and foreign, for the prosecution of research and the encouragement of classical studies, Athens has become once more an international seat of learning. The Greek Archæological Society, founded in 1837, numbers some distinguished scholars among its members, and displays great activity in the conduct of excavations. Important researches at Epidaurus Eleusis, Mycenæ, Amyclæ, and Rhamnus may be numbered among its principal undertakings, in addition to the complete exploration of the Acropolis and a series of investigations in Athens and Attica. The French *École d'Athènes*, founded in 1846, is under the scientific direction of the *Académie des Inscriptions et Belles Lettres*. Among its numerous enterprises have been the extensive and costly excavations at Delos and Delphi, which have yielded such remarkable results. The monuments of the Byzantine Epoch have latterly occupied a prominent place in its investigations. The German Archæological Institute, founded in 1871, has carried out excavations at Thebes, Lesbos, Paros, Athens, and elsewhere; it has also been associated in the great researches at Olympia, Pergamos, and Troy, and in many other important undertakings. The British School, founded in 1886, has been unable, owing to insufficient endowment, to work on similar lines with the French and German institutions: it has, however, carried out extensive excavations at Megalopolis and in Melos, as well as researches at Abae, in Athens (presumed site of the Cynosarges), in Cyprus, and at Naucratis. It has latterly taken part in the exploration of Knossos and other important sites in Crete. The American School, founded in 1882, is supported by the principal universities of the United States. In addition to researches at Sicyon, Platæa, Eretria, and elsewhere, it has undertaken two works of capital importance—the excavation of the Argive Heræon and the exploration of ancient Corinth. An Austrian Archæological Institute was founded in 1898.

Industry and Commerce.

Notwithstanding certain disadvantages inherent in its situation the trade and manufactures of Athens have considerably increased in recent years. Industrial and commercial activity is mainly centred at the Piræus, where 9 cloth and cotton mills, 45 cognac distilleries, 14 steam flour mills, 5 soap manufactories, 13 shipbuilding and engineering works, chair manufactories, tanneries, and a dynamite factory have been established in recent years. The shipbuilding and engineering trades are active and advancing. The export trade is, however, inconsiderable, as the produce of the local industries is mainly absorbed by home consumption. The annual value of exported cognac is about 1,400,000 francs, of raw hides about 700,000 francs. As a place of import, the Piræus surpasses Patras, Syra, and all the other Greek maritime towns, receiving about 53 per cent. of all the merchandise brought into Greece. The principal imports are coal, grain, manufactured articles, and articles of luxury. The total value of exports in 1894 was 9,207,535 francs, of imports, 55,994,191 francs; no later figures have been published. The customs revenue in 1899 was 18,036,425 drachmas. The number of ships entered and cleared in 1898 was 3886 with a tonnage of 3,419,895 tons, of which 217 with a tonnage of 284,365 tons were British.

The Piraeus. The Piraeus, which had never revived since its destruction by the Romans in B.C. 86, was at the beginning of the last century a small fishing village known as Porto Leone. When Athens became the capital in 1834 the ancient name of its port was revived, and since that time piers and quays have been constructed, and spacious squares and broad regular streets have been laid out. The town now possesses an exchange, a large theatre, a gymnasium, municipal buildings, and several hospitals and charitable institutions erected by private munificence. The harbour, in which ships of all nations may be seen, as well as great numbers of the picturesque sailing craft engaged in the coasting trade, is somewhat difficult of access to larger vessels, but will be improved by the construction of new breakwaters and dry docks. The port and the capital are now connected by railway with Corinth and the principal towns of the Morea: a line opening up communication with Northern Greece and Thessaly is in process of construction; its eventual connexion with the Continental railway system will greatly enhance the importance of the Piraeus, already one of the most flourishing commercial towns in the Levant.

Population. The population of Athens has rapidly increased. In 1834 it was below 5000; in 1870 it was 44,510; in 1879, 63,374; in 1889, 107,251; in 1896, 111,486. The Piraeus, which in 1834 possessed only a few hundred inhabitants, in 1879 numbered 21,618; in 1889, 34,327; in 1896, 43,848. The total population of Athens, Piraeus, Phaleron, and the suburbs is now probably little short of 200,000.

BIBLIOGRAPHY.—C. WACHSMUTH. *Die Stadt Athen im Alterthum*, vol. i. Leipzig, 1874; vol. ii. part i. Leipzig, 1890.—E. BURNOUF. *La ville et l'acropole d'Athènes aux diverses époques.* Paris, 1877.—F. C. PENROSE. *Principles of Athenian architecture.* London, 1888.—F. GREGOROVIUS. *Geschichte der Stadt Athen im Mittelalter.* 2 vols. Stuttgart, 1889.—J. E. HARRISON. *Mythology and monuments of ancient Athens.* London, 1890.—E. CURTIUS and A. MILCHHÖFER. *Stadtgeschichte von Athen.* Berlin, 1891.—H. HITZIG and H. BLÜMNER. *Pausanias* (text and commentary), vol. i. Berlin, 1896.—J. G. FRAZER. *Pausanias* (translation and commentary). 6 vols. London, 1898. (The commentary on Pausanias' description of Athens, contained in vol. ii. with supplementary notes in vol. v., is an invaluable digest of recent researches).—H. OMONT. *Athènes au XVII. Siècle.* Paris, 1898. (Plans and views of the town and acropolis and drawings of the sculptures of the Parthenon).—J. H. MIDDLETON and E. A. GARDNER. *Plans and drawings of Athenian buildings.* London, 1900.—W. JUDEICH. *Topographie von Athen.* Munich. (In preparation, forming vol. iii. part ii. second half, in 3rd edition of I. von Muller's *Handbuch der klass. Alterthumswissenschaft.* The corresponding volume in the edition of 1889, by H. G. Lolling, is still of great value). For the Acropolis, see A. BÖTTICHER. *Die Akropolis von Athen.* Berlin, 1888.—O. JAHN. *Pausaniae descriptio arcis Athenarum.* Bonn, 1900.—A. FURTWÄNGLER. *Masterpieces of Greek sculpture* (appendix). London, 1895.—A. MILCHHÖFER. *Ueber die alten Burgheiligthümer in Athen.* Kiel, 1899.—For the Parthenon, A. MICHAELIS. *Der Parthenon.* Text and Plates. Leipzig, 1871.—L. MAGNE. *Le Parthenon.* Paris, 1895.—J. DURM. *Der Zustand der antiken athenischen Bauwerke.* Berlin, 1895.—F. C. PENROSE in *Journal of Royal Institute of British Architects* for 1897.—N. M. BALANOS in 'Εφημερὶς τῆς Κυβερνήσεως. Athens, August 25, 1898.—For the Dionysiac Theatre, A. E. HAIGH. *The Attic Theatre.* Oxford, 1889.—W. DÖRPFELD and E. REISCH. *Das Griechische Theater.* Athens, 1896.—For the "Theseion," B. SAUER. *Das sogenannte Theseion.* Leipzig, 1899.—For the Piraeus, E. I. ANGELOPOULOS. *Περὶ Πειραιῶς καὶ τῶν λιμένων αὐτοῦ.* Athens, 1898.—For the Attic Demes, A. MILCHHÖFER. *Untersuchungen über die Demenordnung des Kleisthenes.* (In Transactions of Berlin Academy). Berlin, 1892.—PAULY-WISSOWA. *Real-Encyclopädie der klass. Alterthumswissenschaft*, vol. ii. 2, article "Attika." Stuttgart, 1896.—For the controversies respecting the Agora, the Enneacrunus and the topography of the town in general, see W. DÖRPFELD, *passim* in *Athenische Mitteilungen.*—C. WACHSMUTH. "Neue Beiträge zur Topographie von Athen," in *Abhandlungen der sächsischen Gesellschaft der Wissenschaften.* Leipzig, 1897.—A. MILCHHÖFER. "Zur Topographie von Athen," in *Berlin Philol. Wochenschrift*, 1900, Nos. 9, 11, 12.—For the Byzantine period, AUGUST MOMMSEN. *Athenæ Christianæ.* Leipzig, 1868.—Periodical Literature. *Mittheilungen des kais. deutsch. arch. Instituts.* Athens, from 1876. *Bulletin de correspondance hellénique*, Athens, from 1877. *Papers of the American School.* New York, 1882-1897. *Annual of the British School.* London, from 1894. *Journal of Hellenic Studies.* London, from 1880. *American Journal of Archæology.* New York, from 1885. *Jahrbuch des kais. deutsch. arch. Instituts.* Berlin, from 1886. The best maps are those in *Die Karten von Attika*, published with explanatory text by the German Archæological Institute, Berlin, 1881. See also Baedeker's *Greece*, London, 1894; Murray's *Greece and the Ionian Islands*, London, 1900. Guide Joanne, vol. i. *Athènes et ses environs*, Paris, 1896.

(J. D. B.)

Athens, a city in the northern part of Georgia, U.S.A., and capital of Clarke county; altitude, 680 feet. It is entered by several railways, and has extensive and growing manufactures, largely of cotton. It is the site of the University of Georgia and of the Lucy Cobb Institute. Population (1880), 6099; (1890), 8639; (1900), 10,245.

Atherton, or CHOWBENT, a township in the Leigh parliamentary division of Lancashire, England, 13 miles W.N.W. of Manchester by rail. A new church has been built and another rebuilt. There is a volunteer hall. Population of urban district in 1881, 12,602; in 1891, 15,833. In 1894 part of the township and urban district was transferred to the urban district of Leigh. Population (1891), on area thus altered, 13,720; (1901), 16,211.

Athletic Sports.—Since 1875 the number of athletic meetings held throughout the United Kingdom has continued to increase, and the number of amateur athletes has become very much greater. The most noticeable feature of the increase during this period is that the movement has spread from the "classes" to the "masses." Except at the universities, public schools, and military colleges, where running and jumping competitions are still carried on with the greatest zest, and retain their social prestige, and in London, where the London Athletic Club still continues to attract members of good standing, throughout the rest of the country the great majority of athletes who compete at meetings are not drawn from the upper or middle classes as was the case twenty or thirty years ago. The form of competitions has hardly varied at all, the competitions at what are called athletic sports, in the limited sense of the word "athletic," being running at short, middle, and long distances, hurdle races, jumping (high and long), weight-putting, and hammer-throwing. The two last named have been falling into desuetude in most parts of England, though still carried on in Scotland and Ireland. A new feature is the increase of what are called steeplechases—*i.e.*, long-distance races over hurdles, water jumps, and other obstacles. A two-mile steeplechase was introduced into the programme of the amateur championship meeting in 1879. Since 1880 the entire management of the amateur championship meeting has been in the hands of a representative body called the Amateur Athletic Association. It is divided into three branches—a northern, midland, and southern—and its general committee manages an annual championship meeting, issues laws, and governs the sport in the same manner as the Jockey Club governs horse-racing. No meeting can be held without the licence of this body, which also licenses the handicappers who allot the starts in open events.

The definition of an amateur adopted by this body is wide, and only excludes those who have competed for money or against a professional pedestrian. There are similar bodies which work under identical rules in Scotland and Ireland. The standard of excellence continues to improve. A carefully-tabulated set of British records is kept by the Amateur Athletic Association, and a copy is appended below. This list is confined to performances done in the United Kingdom.

Another feature of the progress of athletic sports is the growth of the movement in the United States of America, and particularly in the colleges of that country (see below). A party of American athletes took part in the English Championship meeting of 1900 and won the majority of the events, being conspicuously the superiors of the Englishmen in the short-distance races. Indeed, the American records of every distance up to and including half a mile are slightly better than the English. In the longer distances the Englishmen seem more than able to hold their own.

Except at the universities all the athletic meetings in England are now held in the summer months. During the winter the athletes occupy themselves with paper-chases and cross-country races. There are many scores of paper-chasing clubs throughout the country, and the popularity of cross-country running seems to be steadily upon the increase. The only other remaining feature in connexion with athletic sports which requires chronicling is the new method of starting in sprinting or short-distance races. The runner bends down and rests his hands lightly on the starting mark, and no longer "toes the scratch." When the pistol fires he pushes off from his hands and raises himself gradually in the first stride or two. There is no doubt that this is the quickest method of starting, and it is now almost universal.

AMATEUR ATHLETIC ASSOCIATION RECORDS.

Running.

Distance.	Name. Record made by	Time.			Date.
		H.	M.	S.	
Yards.					
100	A. Wharton .			10	3 July 1886
	C. A. Bradley				1 July 1893
	A. R. Downer				4 May 1895
	R. W. Walsley				2 July 1898
	F. W. Cooper				2 July 1898
	C. R. Thomas				8 March 1890
120	W. P. Phillips			11⅘	25 March 1882
	C. A. Bradley				28 April 1894
	A. R. Downer				11 May 1895
[1]120 Hur.	Godfrey Shaw			15⅘	8 July 1895
150	C. G. Wood .			14⅘	21 July 1887
	C. J. Monypenny				27 Feb. 1892
200	E. H. Pelling			19⅘	28 Sept. 1889
	A. R. Downer				11 May 1895
	G. Jordan .				18 March 1896
220	C. G. Wood .			21⅘	25 June 1887
300	,,			31⅘	21 July 1887
440	H. C. L. Tindall			48½	20 June 1889
	E. C. Bredin .				22 June 1895
[2]440 Hur.	T. M. Donovan			57⅘	13 June 1896
600	E. C. Bredin .		1	11⅘	10 June 1893
880	F. J. K. Cross		1	54⅘	9 March 1888
1000	W. E. Lutyens		2	14⅘	5 July 1898
1320	Alec. Nelson .		3	11⅘	26 Aug. 1899
Miles.					
1	F. E. Bacon .		4	17	6 July 1895
1½	S. Thomas .		6	53⅘	13 May 1893
2	W. G. George		9	17⅖	26 April 1884
3	S. Thomas .		14	24	3 June 1894
4	E. C. Willers		19	33⅘	10 June 1894
5	S. Thomas .		24	53⅗	24 Sept. 1893
6	,,		30	17⅘	22 Oct. 1892
7	,,		35	36⅘	,,
8	W. G. George		40	57⅘	28 July 1884
9	,,		46	12	7 April 1884
10	,,		51	20	,,
12	S. Thomas .	1	2	43	22 Oct. 1892
15	,,	1	22	15⅗	,,
20	G. Crossland .	1	51	54	22 Sept. 1894
25	G. A. Dunning	2	33	44	28 Dec. 1881
30	J. A. Squires	3	17	36½	2 May 1885
40	G. A. Dunning	4	50	12	26 Dec. 1879
50	J. E. Dixon .	6	18	26⅕	11 April 1885
100	No records.				

Walking.

Distance.	Name. Record made by	Time.			Date.
		H.	M.	S.	
Miles.					
1	W. J. Sturgess .		6	33⅗	26 Sept. 1896
2	,,		13	24⅘	10 July 1897
3	,,		21	14	3 July 1897
4	,,		28	24⅘	,,
5	,,		36	27	19 Oct. 1895
6	,,		43	58⅗	,,
7	,,		51	27	,,
8	,,		58	56	,,
9	,,	1	9	31⅗	3 Oct. 1896
10	,,	1	17	38⅘	,,
11	,,	1	25	53⅗	,,
12	,,	1	34	31	23 Oct. 1897
13	,,	1	42	59⅘	,,
14	J. Butler .	1	52	18⅘	23 Oct. 1897
15	,,	2	0	43⅗	..
16	,,	2	9	39	,,
17	,,	2	18	56⅗	,,
18	,,	2	28	52	,,
19	,,	2	39	3⅗	,,
20	[3]Tom Griffith .	2	47	52	3 Dec. 1870
	J. Butler .	2	49	26	23 Oct. 1897
21	,,	2	59	42⅘	,,
25	W. E. N. Coston	3	53	35	27 Dec. 1880
30	,,	4	46	52	,,
40	[3]A. W. Sinclair	6	38	3	14 Nov. 1879
	J. A. McIntosh	7	1	44	2 Oct. 1886
50	[3]A. W. Sinclair	8	25	25½	14 Nov. 1879
	J. A. McIntosh	8	52	25	2 Oct. 1886
75	[3]A. W. Sinclair	14	10	0	27 Aug. 1881
100	[3] ,,	19	41	50	,,

Time Records.

Event.	Name. Record made by	Distance.	Date.
		M. YDS.	
2 hours' run .	G. Crossland .	20½ …	22 Sept. 1894
1 hour walk .	W. J. Sturgess .	8 270	19 Oct. 1895
3 hours' walk .	J. Butler .	21 49	23 Oct. 1897
12 ,,	A. W. Sinclair .	64 180	27 Aug. 1881
		H. M. S.	
London (Westminster Clock Tower) to Brighton (52½ miles) (walk)	E. Knott .	8 56 44	10 April 1897

Odd Events.

Event.	Name. Record made by	Distance.	Date.
		FT. IN.	
High jump .	P. H. Leahy .	6 4⅝	8 Sept. 1898
Pole jump .	R. D. Dickenson .	11 9	1891
Long jump[4] .	W. J. M. Newburn	24 0½	16 July 1898
Putting the shot (16 lb)	D. Horgan .	46 5½	15 Aug. 1894
Throwing the hammer (16lb)	T. F. Keily .	151 11	25 July 1898

(M. S.)

United States.—The American adopted all his sports, except base-ball, from the English; but, as in the case of American political institutions, while the origins have been English the genius of the people has determined the lines of development. All forms of athletic contests tend in America to become shorter and more intense. The national game of base-ball, for instance, is nervous and rapid in its movement, as compared with cricket. A base-ball contest is decided in two hours, as against the day or more required for a game of cricket; and instead of the two long innings there are nine short innings, in the course of which the score may be half-a-dozen times reversed. Again, in American football, which developed from the Rugby Union game, the contrast is equally striking, the American game having developed a thoroughly-planned and dramatic series of manœuvres often of much complexity. In track and field athletics the performances of Americans are as excellent in all contests requiring a single burst of nervous energy, such as sprinting, hurdling, and jumping, as those of English athletes are in the longer runs. It was not until shortly before the Civil War (1861-65) that there seemed to spring up something of athletic interest in America—boating being almost the only sport which until that time possessed any rules and permanent organizations. But the period of the war interrupted what might have been a speedy development along English lines. After peace was established, athletics appeared to take root once more, and in the succeeding decade (1870-79) there was a rapid increase in general organization and interest. Rowing, which had been less interrupted during the war, and had had a longer existence than the other sports, came once more into prominence, and especial interest was added by the inter-collegiate regattas and by the centennial races (1876). Football was still in a chaotic stage, but the year 1876 saw the inauguration of the Rugby Union rules, and with them the beginning of football as it is played to-day in the United States. Base-ball had for some half-dozen years been decidedly successful in the colleges, and among both amateurs and professionals outside. Track athletics, which had hitherto been only incidental to college boat-racing, had now made an independent place for itself. Thus in 1876 the four principal American sports had begun to push forward along the lines which were followed during the next quarter of a century.

---

[1] On grass.

[2] Hurdle race on grass, over ten 3 ft. hurdles not less than thirty yards apart.

[3] In matches against time.

[4] P. O'Connor jumped 24 ft. 11¾ in. at Kilkenny, 15th July 1901.

In rowing, since the introduction of eight-oared shell racing over a four-mile course, there has been but little variation, this distance and this number of oars proving the most satisfactory. Upon several occasions there has been an agitation in favour of shortening the distance or of altering the methods in one way or another, but the movement has not met with more than temporary favour. In football the growth has been most rapid and most distinctly American—though here the rules adopted originally were those of the Rugby Union—and at first there was no legislation save where the rule failed specifically to cover a disputed point, and where there was only tradition to be relied upon. But with the growth of the game rule-making became necessary, and the inventive genius of the American player developed special "plays" and formations until now the game is almost as distinctly American as base-ball. Track athletics had a very small beginning, but was taken up by an increasing number of colleges; more events were added, and greater interest was developed, until it grew in the last twenty years of the 19th century into a well-equipped and permanent branch of amateur sport. In fact, there is no branch which has as much strength among athletic clubs outside the colleges as track athletics. The new sports since 1875 are bicycling, tennis, and golf, together with the minor sports of basket ball, hockey, and polo. Tennis has both waxed and waned in the same period, but is now once more gaining in popularity, and bids fair to secure and maintain a permanent place. Golf has withdrawn many from the tennis ranks, and is probably as widely engaged in to-day as any sport in the country, largely owing to the fact that it can be played by individuals who have passed the age for the more violent athletic sports.

In the country at large the percentage of men who engage in athletic pastimes has been almost inappreciable. Professional sport is limited to leagues of base-ball teams representing the great cities; and the main cultivation of amateur sport outside the universities is in the great athletic clubs which are now to be found in many of the large cities. These clubs differ from such organizations as the London Athletic Club in that they maintain large club-houses, which, in addition to expensively equipped gymnasiums, have luxurious lounging rooms, billiard rooms, and marble swimming baths. The ruling spirit is social rather than athletic. They have been strongly influenced by university sportsmen and sports, but the university element has never been dominant. The sports most successfully pursued are track and field athletics. Those sports which require more extensive organization and preparation, such as base-ball, football, and rowing, are practised with indifferent success. The oldest and most characteristic development of sport has been, as in England, in the universities, but even the percentage of men engaged has not been large. Whereas in England almost 80 per cent. of the undergraduates engage in some athletic pastime, the percentage of American undergraduate athletes had not until the closing decades of the 19th century exceeded 20; and even in those universities in which athletics are most enthusiastically pursued, the percentage is not yet even 40. This is in part due to the intensity characteristic of sports, and in part to the lack of that athletic rivalry within the university, and the consequent multiplication of contests, which is afforded in England by the division of the university into colleges. Whereas an English 'varsity crew is content to row together for a month or two, the candidates for an American crew that is to race in July usually train in a gymnasium through the greater part of the preceding winter. And whereas in England football teams rely on practice games and a few informal "squashes," an American team, in addition to one or two practice games a week, works hard every afternoon in developing complicated "plays" and in perfecting team work.

The methods of training and the spirit of sportsmanship have shown a very characteristic development. Owing partly to the extremes of the climate and the severity of nervous tension induced by it, and partly to the lack of more general participation in sports, the training has become in all instances more elaborate and more thorough than in England, and the winning of athletic victories is considered of more importance. Rivalries have been, and still are, of great intensity. At the same time the athletic spirit has run into grave excesses. All college teams have at one time or another been under strong and well-founded suspicion of inducing athletes to play for them by improper means. Excessive partisanship has involved excessive training, crafty diplomacy in arranging games, and trickery. All of the objectionable features have been intensified by the fact that the great games have often been held in the cities, where they are apt to take on the character of public gladiatorial contests. In the closing decade of the 19th century a marked reaction began. The publicity attending university sports gave occasion for a vigorous protest against all forms of unsportsmanship, and the members of the university faculties now exercise a strong and, in many cases, a wise supervision. Except in occasional instances, for which individuals only are responsible, the representatives of the eastern universities are amateurs in the full sense of the word: and in the western universities, where the development of sports was very sudden, and was attended by flagrant abuse, wise counsels prevail. The spirit of moderation has been strongly abetted by the abandonment of the old league championships in favour of independent meetings between one college and another; and this practice in turn tends to limit inter-university games to university grounds. The rapid increase, moreover, in the popularity of minor sports has drawn ever-increasing numbers of men into active competition, and there is a strong tendency to develop contests within the university. On becoming more general, the athletic spirit has become less intense. Though American sports will doubtless always retain the peculiar strenuousness of the American character, the influences controlling them are becoming more and more representative of the best spirit in American life.

The American amateur records for the events most commonly competed for in track and field athletics are as follows:—

Running, 100 yards	9⅘ sec.
,, 220 ,,	21⅕ ,,
,, 440 ,,	47 ,,
,, 880 ,,	1 min. 53⅖ ,,
,, 1 mile	4 ,, 15⅗ ,,
,, 3 miles	14 ,, 24 ,,
Walking, 1 mile	6 ,, 29⅗ ,,
Hurdles, 120 yards (five hurdles, 3 ft. 6 in. high)	15⅕ ,,
,, 220 ,, (ten hurdles, 2 ft. 6 in. high)	23⅗ ,,
Jumping, standing high, without weights	5 feet 4 inches
,, running high, without weights	6 ,, 5⅝ ,,
,, running long, without weights	24 ,, 7¼ ,,
Pole vault for height	11 ,, 10⅞ ,,
Throwing the hammer, 16 lb. head (thrown by both hands from a mark; handle 4 feet long)	113 ,, 11 ,,
Ditto from circle	175 ,, 4⅜ ,,
Putting the shot, 16 lb	47 ,,

(W. CA.)

Athlone, a market town and urban sanitary district in the county of Westmeath, province of Leinster, Ireland, on both sides of the river Shannon, 76 miles west of Dublin by rail. It ceased to be a parliamentary borough in 1885. In 1898 the portion situated in Roscommon was added to Westmeath. A woollen mill has been recently established, in addition to the already existing factory. Population (1881), 6755; (1891), 6742; (1901), 6617.

Athol, a town of Worcester county, northern Massachusetts, U.S.A., having an area of 35 square miles. Its surface is quite irregular and hilly. The village of Athol is on the Miller river, at an altitude of 556 feet, and is entered by two railways, the Boston and Albany and the Fitchburg. The plan of the village is quite irregular. Athol was incorporated in 1762. Population (1880), 4307; (1890), 6319; (1900), 7061.

Athos, the most easterly of three peninsulas of Turkey in Europe, projecting at its south-western extremity into the Ægean Sea. The north-western border is about 50 miles S.E. of Salonica, to which there is a bridle-path. The peninsula takes its name from Mount Athos (6350 feet), the extreme summit of a chain of heights occupying the peninsula; and on account of the number of religious houses, now totalling about 1000, it is also known as "the Holy Mount." None but males are allowed access to the peninsula, and all the inhabitants are Christians, with the exception of one Turkish officer. The recluses number about 3000, with 3000 servants.

AUTHORITIES.—RILEY. *Athos, or the Mountain of the Monks.* London, 1887.—BROCKHAUS. *Die Kunst in den Athos-Klöstern.* Leipsic, 1891.—LAMBROS. *Catalogue of the Greek Manuscripts on Mount Athos.* Cambridge, vol. i., 1895.—MEYER. *Die Haupturkunden für die Geschichte der Athos-Klöstern.* Leipsic, 1894.

Atkinson, Major the Hon. Sir Harry Albert, K.C.M.G. (1831-1892), British colonial statesman; prime minister and Speaker of the legislative council, New Zealand; was born at Chester in 1831, and in 1855 emigrated to Taranaki, New Zealand, where he became a farmer. In 1860 the Waitara war broke out, and from its outset Atkinson, who had been selected as a captain of the New Plymouth Volunteers, distinguished himself by his contempt for appearances and tradition, and by the practical skill, energy, and courage which he showed in leading his Forest Rangers in the tiresome and lingering bush warfare of the next five years. For this work he was made a major of militia, and thanked by the Government. Elected to the house of representatives in 1863, he joined Sir Frederick Weld's ministry at the end of November 1864 as minister of defence, and, during eleven months of office, was identified with the well-known "self-reliance" policy, a proposal to dispense with imperial regulars, and meet the Maori with colonials only. Parliament accepted this principle, but turned out the Weld ministry for other reasons. For four years Atkinson was out of parliament; in October 1873 he re-entered it, and a year later became minister of lands under Sir Julius Vogel. Ten months later he was treasurer, and such was his aptitude for finance that, except during six months in 1876, he thenceforth held that post whenever his party was in power. From October 1874 to January 1891, Atkinson was only out of office for about five years. Three times he was premier, and he was always the most formidable debater and fighter in the ranks of the Conservative opponents of the growing Radical party which Grey, Stout, and Ballance led in succession. It was he who was mainly responsible for the abolition of the provinces into which the colony was divided from 1853 to 1876. He repealed the Ballance land-tax in 1879, and substituted a property-tax. He greatly reduced the cost of the public service in 1880, and again in 1888. In both these years he raised the customs duties, amongst other taxes, and gave them a quasi-protectionist character. In 1880 he struck 10 per cent. off all public salaries and wages; in 1887 he reduced the salary of the governor by one-third, and the pay and number of ministers and members of parliament. By these resolute steps revenue was increased, expenditure checked, and the colony's finance reinstated. Atkinson was an advocate of compulsory national assurance, and the leasing as opposed to the selling of crown lands. Defeated in the general election of December 1890, he took the appointment of Speaker of the legislative council. There, while leaving the council chamber after the sitting of 28th June 1892, he was struck down by heart disease, and died in a few minutes. Though brusque in manner, and never popular, he was esteemed as a vigorous, upright, and practical statesman. He was twice married, and had seven children, of whom three sons and a daughter survived him. (W. P. R.)

Atlanta, the largest city of Georgia, U.S.A., capital of the state and of Fulton county. It is situated in the northern part of the state, in 33° 45′ N. lat. and 84° 24′ W. long., at an altitude of 1050 feet. Its mean annual temperature is 62°, and the annual rainfall is 45 inches. The city is regularly laid out, is divided into seven wards, is supplied with water by the Holly pumping system, and is well drained and paved. It is one of the principal railway centres of the south, being entered by six railways, the Atlanta and West Point, the Central of Georgia, the Georgia, the Seaboard Air Line, the Southern, and the Western and Atlantic, which meet at a union depot. Amongst several institutions for higher education are the Atlanta Baptist College, Atlanta University, Morris Brown College, and the State Normal School of Technology. Of its newspapers the *Atlanta Constitution* is well known throughout the Union. Among the many fine buildings of the city the State Capitol, erected at a cost of $1,000,000, should be mentioned. Atlanta is probably the most progressive city of the south, having made vast strides during the past generation. In 1890 it had 410 manufacturing establishments of all kinds, employing

$9,500,000 of capital, and 8684 persons. Chief among these were cotton manufactories, in which $1,900,000 were invested, and foundries and machine shops, with nearly $1,000,000. Lumber and furniture factories are also of great importance. The assessed valuation of property, real and personal, was, in 1899, $52,240,058, the tax rate $21.60 per $1000, and the indebtedness of the municipality $2,808,910. The death-rate, 23·01 per 1000, is enhanced by the large proportion of negroes among the population. Since the Civil War, which practically destroyed it, the city has grown with great rapidity. Population (1880), 37,409; (1890), 65,533; (1900), 89,872, of whom 2531 were foreign-born and 35,912 were negroes.

Atlantic, capital of Cass county, Iowa, U.S.A., situated on the East Nishnabotna river, at the intersection of the Chicago, Rock Island, and Pacific railway with a branch of the Chicago, Burlington, and Quincy railway. Population (1890), 4351; (1900), 5046.

Atlantic City, a city of Atlantic county, New Jersey, U.S.A., situated in 39° 22' N. lat. and 74° 26' W. long., on a sand-bar running parallel with the coast, and separated from the mainland by a strip of marsh about five miles in breadth. The city is but slightly elevated above tide-level, is regularly laid, and is divided into four wards. Water is supplied by pumping, the water-works being privately owned. It is a popular seaside resort both in summer and winter, especially with dwellers in Philadelphia, with which city it is connected by two railways, the Atlantic City (Philadelphia and Reading system) and the West Jersey and Seashore (Pennsylvania system). It is a city of hotels and boarding-houses, and in the summer season has a large floating population, estimated at 100,000. The first settlement was made about 1783, and the place received a city charter in 1852. Population (1880), 5477; (1890), 13,055; (1900), 27,838.

Atlantic Ocean.—The Atlantic Ocean forms a belt of water, roughly of an S-shape, between the western coasts of Europe and Africa and the eastern coasts of North and South America. It extends northwards to the Arctic Basin and southwards to the Great Southern Ocean. For purposes of measurement the polar boundaries are taken to be the Arctic and Antarctic circles, although in discussing the configuration and circulation it is impossible to adhere strictly to these limits. The Atlantic Ocean consists of two characteristic divisions, the geographical equator forming a fairly satisfactory line of division into North and South Atlantic. The North Atlantic, by far the best known of the main divisions of the hydrosphere, is remarkable for the immense length of its coast-line and for the large number of enclosed seas connected with it, including on the western side the Caribbean Sea and Gulf of Mexico, the Gulf of St Lawrence, and Hudson Bay, and on the eastern side the Mediterranean and Black Sea, the North Sea, and the Baltic. The North Atlantic is connected with the Arctic Basin by four main channels: (1) Hudson Strait, about 60 miles wide, communicating with the gulfs and straits of the North American Arctic archipelago; (2) Davis Strait, about 200 miles wide, leading to Baffin Bay; (3) Denmark Strait, between Greenland and Iceland, 130 miles wide; and (4) the "Norwegian Sea," about 400 miles wide, extending from Iceland to the Faroe Islands, the Shetland Islands, and the coast of Norway. The width of the North Atlantic in lat. 60°, approximately where it breaks up into the branches just named, is nearly 2000 miles; in about lat. 50° N., the coasts of Ireland and Newfoundland approach to 1750 miles; the breadth then increases rapidly to lat. 40° N., and attains its maximum of 4500 miles in lat. 25° N.; farther south the minimum breadth is reached between Africa and South America, Cape Palmas being only 1600 miles distant from Cape St Roque. In marked contrast to this, the South Atlantic is distinguished by great simplicity of coast-line; inland seas there are none, and it attains its greatest breadth as it merges with the Southern Ocean; in lat. 35° S. the width is 3700 miles.

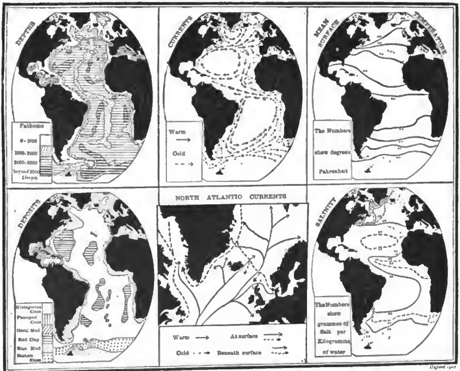
The total area of the North Atlantic, not counting inland seas connected with it, is, according to Karstens, 36,438,000 square kilometres, or 10,588,000 square miles; including the inland seas the area is 45,641,000 square kilometres, or 13,262,000 square miles. The area of the South Atlantic is 43,455,000 square kilometres, or 12,627,000 square miles. Although not the most extensive of the great oceans, the Atlantic has by far the largest drainage area. The "long slopes" of the continents on both sides are directed towards the Atlantic, which accordingly receives the waters of a large proportion of the great rivers of the world, including the St Lawrence, the Mississippi, the Orinoco, the Amazon, the rivers of the La Plata, the Congo, the Niger, the Loire, the Rhine, the Elbe, and the great rivers of the Mediterranean and the Baltic. Murray estimates the total area of land draining to the Atlantic to be 13,432,000 square miles, or with the Arctic area nearly 20,000,000 square miles, nearly four times the area draining to the Pacific Ocean, and almost precisely four times the area draining to the Indian Ocean. Murray's calculations give the amount of precipitation received on this area at 15,800 cubic miles annually, and the river discharge from it at 3900 cubic miles.

Relief of the bed.

The dominant feature of the relief of the Atlantic basin is a submarine ridge running from north to south from about lat. 50° N. to lat. 40° S., almost exactly in the central line, and following the S-shape of the coasts. Over this ridge the average depth is about 1700 fathoms. Towards its northern end the ridge widens and rises to the plateau of the Azores, and in about 50° N. lat. it merges with the "Telegraph Plateau," which extends across nearly the whole ocean from Ireland to Newfoundland. North of the fiftieth parallel the depths diminish towards the north-east, two long submarine ridges of volcanic origin extend north-eastwards to the south-west of Iceland and to the Faroe Islands, and these, with their intervening valleys, end in a transverse ridge connecting Greenland, through Iceland and the Faroe Islands, with North-western Scotland and the continental mass of Europe. The mean depth over this ridge is about 250 fathoms, and the maximum depth nowhere reaches 500 fathoms. The main basin of the Atlantic is thus cut off from the Arctic basin, with which the area north of the ridge has complete deep-water communication. This intermediate region, which has Atlantic characteristics down to 300 fathoms, and at greater depths belongs more properly to the Arctic Sea, commonly receives the name of Norwegian Sea. On both sides of the central ridge deep troughs extend southwards from the Telegraph plateau to the Southern Ocean, the deep water coming close to the land all the way down on both sides. In these troughs the depth is seldom much less than 3000 fathoms, and this is exceeded in a series of patches to which Murray has given the name of "Deeps." In the eastern trough the *Peake deep* lies off the Bay of Biscay in 20° W. long., *Monaco deep* and *Chun deep* off the north-west of Africa, *Moseley deep* off the Cape Verde Islands, *Krech deep* off the Liberian coast, and *Buchanan deep* off the mouth of the Congo. The western trough extends northwards into Davis Strait, forming a depression in the Telegraph plateau; to the south of Newfoundland

and Nova Scotia are *Sigsbee deep*, *Thoulet deep*, *Libbey deep*, and *Suhm deep*, each of small area; north-east of the Bahamas *Nares deep* forms the largest and deepest depression in the Atlantic, in which a sounding of 4561 fathoms was obtained (70 miles north of Porto Rico) by the U.S. ship *Blake* in 1883. Immediately to the south of Nares deep lies the smaller *Makaroff deep*; and off the coast of South America are *Tizard deep* and *Havergal deep*. South of 40° S. lat. the form of the sea-bottom changes considerably on account of the eastward trend taken by the alternate elevations and depressions. Between the southern extremity of South America and Graham Land, in the Antarctic, the depth nowhere reaches 2000 fathoms, and a plateau of less depth extends eastward to South Georgia and the Sandwich group. In 40° S. lat., 40° W. long., the 3000-fathoms line marks an offshoot of the great *Ross deep*, which runs south-eastwards to the main depression. East of this trough the depth is, generally, over 2000 fathoms, except where a bank, on which Bouvet Island stands, suggests a south-easterly prolongation of the main central ridge, which, but for this, would appear to end at Tristan da Cunha. From the south point of Africa south-eastwards to the Crozet Islands and Kerguelen the depth is less than 2000 fathoms, an ill-defined ridge separating the eastern margin of the Ross deep from the main basin of the Indian Ocean (*q.v.*)

The foundations of our knowledge of the relief of the Atlantic basin may be said to have been laid by the work of H.M.S. *Challenger* (1873-76), of the German ship *Gazelle* (1874-76), the French expedition in the *Travailleur* (1880), and the U.S. surveying vessel *Blake* (1877 and later). Large numbers of additional soundings have been made in recent years by cable ships, by the expeditions of H.S.H. the Prince of Monaco, and by the German *Valdivia* expedition under Professor Chun (1898); but with the exception of the last-named none of the later workers have seriously modified the contours outlined by the *Challenger* and *Gazelle*.



Volume, mean depth, and bottom deposits.

For the volume of the North Atlantic, Karstens gives the value 136,384,000 cubic kilometres, or 21,362,000 cubic miles, giving a mean depth of 2047 fathoms. If we include the enclosed seas, the North Atlantic has a volume of 150,415,000 cubic kilometres, or 23,560,000 cubic miles, giving a mean depth of 1800 fathoms. The South Atlantic has a total volume of 164,263,000 cubic kilometres, or 25,729,000 cubic miles, giving a mean depth of 2067 fathoms. The following table, due to Murray, gives details of the area of the floor of the Atlantic basin, and the volume of water resting thereon, at different levels:—

Depth. Fathoms.	Area. Square Miles.	Volume. Cubic Miles.
Between		
0- 100	2,907,003	2,353,703
100- 500	2,404,482	8,370,611
500-1000	1,840,634	9,568,637
1000-2000	5,468,015	15,816,901
2000-3000	10,928,918	8,905,287
3000-4000	1,780,012	690,123
Over 4000	5,832	2,155
	25,334,896	45,707,417

Mean depth, 1830 fathoms.

The Atlantic Ocean contains a relatively small number of islands. The only continental groups, besides some islands in the Mediterranean, are Iceland, the British Isles, Newfoundland, the West Indies, and the Falklands, and the chief oceanic islands are the Azores, Madeira, the Canaries, the Cape Verde Islands, Ascension, St Helena, Tristan da Cunha, and Bouvet Island.

The greater part of the bottom of the Atlantic is covered by a deposit of Globigerina ooze, roughly the area between 1000 and 3000 fathoms, or about 60 per cent. of the whole. At a depth of about 3000 fathoms, *i.e.*, in the "Deeps," the Globigerina ooze gradually gives place to red clay. In the shallower tropical waters, especially on the central ridge, considerable areas are covered by Pteropod ooze, a deposit consisting largely of the shells of pelagic molluscs. Diatom ooze is the characteristic deposit in high southern latitudes. The terrigenous deposits consist of blue muds, red muds (abundant along the coast of Brazil, where the amount of organic matter present is insufficient to reduce the iron in the matter brought down by the great rivers to produce blue muds), green muds and sands, and volcanic and coral detritus.

The question of the origin of the Atlantic basin, like that of the other great divisions of the hydrosphere, is still unsettled. Most geologists include the Atlantic with the other oceans in the view they adopt as to its age (see GEOLOGY and OCEANOGRAPHY); but Suess and Neumayr, while they regard the basin of the Pacific as of great antiquity, believe the Atlantic to date only from the Mesozoic age. Neumayr finds evidence of the existence of a continent between Africa and South America, which protruded into the central North Atlantic, in Jurassic times. Kossmat has shown that the Atlantic had substantially its present form during the Cretaceous period.

Distribution of temperature.

In describing the mean distribution of temperature in the waters of the Atlantic it is necessary to treat the northern and southern divisions separately. The heat equator, or line of maximum mean surface temperature, starts from the African coast in about 5° N. lat., and closely follows that parallel to 40° W. long., where it bends northwards to the Caribbean Sea. North of this line, near which the temperature is a little over 80° F., the gradient trends somewhat to the east of north, and the temperature is slightly higher on the western than on the eastern side until, in 45° N. lat., the isothermal of 60° F. runs nearly east and west. Beyond this parallel the gradient is directed towards the north-west, and temperatures are much higher on the European than on the American side. From the surface to 500 fathoms the general form of the isothermals remains the same, except that instead of an equatorial maximum belt there is a focus of maximum temperature off the eastern coast of the United States. This focus occupies a larger area and becomes of greater relative intensity as the depth increases until, at 500 fathoms, it becomes an elongated belt extending right across the ocean in about 30° N. lat. Below 500 fathoms the western centres of maximum disappear, and higher temperatures occur in the eastern Atlantic off the Iberian peninsula and North-western Africa down to at least 1000 fathoms; at still greater depths temperature gradually becomes more and more uniform. The communication between the Atlantic and Arctic basins being cut off, as already described, at a depth of about 300 fathoms, the temperatures in the Norwegian Sea below that level are essentially Arctic, usually below the freezing-point of fresh water, except where the distribution is modified by the surface circulation. The isothermals of mean surface temperature in the South Atlantic are in the lower latitudes of an ∞-shape, temperatures being higher on the American than on the African side. In latitudes south of 30° S. the curved form tends to disappear, the lines running more and more directly east and west. Below the surface a focus of maximum temperature appears off the coast of South America in about 30° S. lat., and of minimum temperature north and north-east of this maximum. This distribution is most marked at about 300 fathoms, and disappears at 500 fathoms, beyond which depth the lines tend to become parallel and to run east and west, the gradient slowly diminishing.

Salinity.

The Atlantic is by far the saltest of the great oceans. Its saltest waters are found at the surface in two belts, one extending east and west in the North Atlantic between 20° and 30° N. lat., and another of almost equal salinity extending eastwards from the coast of South America in 10° to 20° S. lat. In the equatorial region between these belts the salinity is markedly less, especially in the eastern part. North of the North Atlantic maximum the waters become steadily fresher as latitude increases until the channels opening into the Arctic basin are reached. In all of these water of relatively high salinity appears for a long distance towards the north on the eastern side of the channel, while on the western side the water is comparatively fresh. In the higher latitudes of the South Atlantic the salinity diminishes steadily and tends to be uniform from east to west, except near the southern extremity of South America, where the surface waters are very fresh. Our knowledge of the salinity of waters below the surface is as yet very defective, large areas being still unrepresented by a single observation. The chief facts already established are the greater saltness of the North Atlantic compared with the South Atlantic at all depths, and the low salinity at all depths in the eastern equatorial region, off the Gulf of Guinea.

Meteorology.

It is now generally admitted that the movements of the surface waters of the great oceans are primarily controlled by the winds, and the resulting circulation consists of (*a*) drift currents in the open sea, following the general wind directions, and (*b*) stream currents, which are independent of the local winds, but are due to inequalities of pressure produced by the interference of land masses with the movements of the drift currents. Quite recently Pettersson has shown that the formation and melting of polar ice must be regarded as a factor contributing a considerable portion of the energy of ocean currents, and this factor must be of great importance in the Atlantic. The wind circulation over the Atlantic is of a very definite character. In the South Atlantic the narrow land surfaces of Africa and South America produce comparatively little effect in disturbing the normal planetary circulation. The tropical belt of high atmospheric pressure is very marked in winter; it is weaker during the summer months, and at that season the greater relative fall of pressure over the land cuts it off into an oval-shaped anticyclone, the centre of which rests on the coolest part of the sea surface in that latitude, near the Gulf of Guinea. South of this anticyclone, from about the latitude of the Cape, we find the region where, on account of the uninterrupted sea surface right round the globe, the planetary circulation is developed to the greatest extent known; the pressure gradient is exceedingly steep, and the region is swept continuously by strong westerly winds—the "roaring forties." This is merely the "polar eddy," which is probably arrested by the frictional resistance of the land and the low temperatures in the higher Antarctic latitudes.

In the North Atlantic the distribution of pressure and resulting wind circulation are very largely modified by the enormous areas of land and frozen sea which surround the ocean on three sides. The tropical belt of high pressure persists all the year round, but the immense demand for air to supply the ascending currents over the heated land surfaces in summer causes the normal descending movement to be largely reinforced, hence the "North Atlantic anticyclone" is much larger, and its circulation more vigorous, in summer than in winter. Again, during the winter months pressure is relatively high over North America, Western Eurasia, and the Arctic regions; hence vast quantities of air are brought down to the surface, and circulation must be kept up by ascending currents over the ocean. The Atlantic anticyclone is therefore at its weakest in winter, and on its polar side the polar eddy becomes a trough of low pressure, extending roughly from Labrador to Iceland and Jan Mayen, and traversed by a constant succession of cyclones. The net effect of the surrounding land is, in fact, to reverse the seasonal variations of the planetary circulation, but without destroying its type. In the intermediate belt between the two high-pressure areas the meteorological equator remains permanently north of the geographical equator, moving between it and about 11° N. lat.

The wind circulation may shortly be described thus from north to south :—

1. "Iceland" depression—low-pressure belt, traversed by numerous cyclones, some of great intensity, in winter; abundant rainfall.

2. A belt of "westerly variables," the polar side of the Atlantic anticyclone, merging into (1).

3. Calm and dry belt, the axis of the Atlantic anticyclone—the "horse latitudes," or "calms of Cancer."

4. Belt of N.E. and E. winds. These coming from a high-pressure area are dry, hence there is little rainfall, and great evaporation from the sea surface, which attains its greatest salinity in this region; the "trade winds."

5. Equatorial belt of calms and rains; the "doldrums."

6. Belt of S.E. and E. winds—the "trade winds."

7. Tropical calm and dry belt, or "calms of Capricorn."

8. Belt of W. and N.W. winds, merging into the "roaring forties."

Currents.

The part of this circulation which is steadiest in its action is the trade winds, and this is therefore the most effective in producing drift movement of the surface waters. The trade winds give rise, in the region most exposed to their influence, to two westward-moving drifts—the *equatorial currents*, which are separated in parts of their course by currents moving in the opposite direction along the equatorial belt. These last may be of the nature of "reaction" currents; they are collectively known as the *equatorial counter-current*. On reaching the South American coast, the southern equatorial current splits into two parts at Cape St Roque: one branch, the *Brazil current*, is deflected southwards and follows the coast as a true stream current at least as far as the River Plate. The second branch proceeds north-westwards towards the West Indies, where it mingles with the waters of the northern equatorial; and the two drifts, blocked by the ◁-shape of the land, raise the level of the surface in the Gulf of Mexico, the Caribbean Sea, and in the whole area outside the West Indies. This congestion is relieved by what is probably the most rapid and most voluminous stream current in the world, the *Gulf Stream*, which runs along the coast of North America, separated from it by a narrow strip of cold water, the "cold wall," to a point off the south-east of Newfoundland. At this point the Gulf Stream water mixes with that from the *Labrador current* (see below), and a drift current eastwards is set up under the influence of the prevailing westerly winds: this is generally called the *Gulf Stream drift*. When the Gulf Stream drift approaches the eastern side of the Atlantic it splits into two parts, one going southwards along the north-west coast of Africa, the *Canaries current*, and another turning northwards and passing to the west of the British Isles. Most of the Canaries current re-enters the northern equatorial, but a certain proportion keeps to the African coast, unites with the equatorial return currents, and penetrates into the Gulf of Guinea. This last feature of the circulation is still somewhat obscure; it is probably to be accounted for by the fact that on this part of the coast the prevailing winds, although to a considerable extent monsoonal, are off-shore winds, blowing the surface waters out to sea, and the place of the water thus removed is filled up by water derived either from lower levels or from "reaction" currents.

The movements of the northern branch of the Gulf Stream drift have been the object of more careful and more extended study than all the other currents of the ocean put together, except, perhaps, the Gulf Stream itself. The cruises of the *Porcupine* and *Lightning*, which led directly to the despatch of the *Challenger* expedition, were altogether within its "sphere of influence"; so also was the great Norwegian North Atlantic expedition. More recently, the area has been further explored by the German expedition in the ss. *National*, the Danish *Ingolf* expedition, and the minor expeditions of the *Michael Sars*, *Jackal*, *Research*, &c. Much has also been done by the discussion of observations made on board vessels belonging to the mercantile marine of various countries. It may now be taken as generally admitted that the current referred to breaks into three main branches. The first passes northwards, most of it between the Faroe and Shetland Islands, to the coast of Norway, and so on to the Arctic basin, which, as Nansen has shown, it fills to a great depth. The second, the *Irminger stream*, passes up the west side of Iceland; and the third goes up the Greenland side of Davis Strait to Baffin Bay. These branches are separated from one another at the surface by currents moving southwards: one, the importance of which has only recently been recognized, to the east of Iceland; the second, the *Greenland current*, skirts the east coast of Greenland; and the third, the *Labrador current* already mentioned, follows the western side of Davis Strait. Pettersson has recently shown that these cold surface currents are chiefly due to the melting of sea ice, caused by the influx of immense quantities of warm water from the Gulf Stream drift, and this result has been confirmed by Dickson, who shows, from an investigation of the seasonal changes of the circulation, that a drift of the kind described is inadequate to account for all the facts. He maintains that, just as in the case of the equatorial currents, a heaping-up of water takes place off the south-west coast of Europe and the north-west of Africa, and that this heaping-up takes place especially in summer, when the Atlantic anticyclone produces its maximum effect. The heaped-up water escapes by stream currents of the same nature as the Gulf Stream; and it is these currents, not the drifts, which are able to make their way into high latitudes, guided by the outline of the land. During winter, when the Atlantic anticyclone is at its weakest and the surface circulation is especially under the control of the cyclones of the Iceland depression, a general drift circulation is set up, large quantities of water move south-eastwards from Davis Strait, cross the Atlantic, and pass north-eastwards into the Norwegian Sea.

The development of the equatorial and the Brazil currents in the South Atlantic has already been described. On the polar side of the high-pressure area a west wind drift is under the control of the "roaring forties," and on reaching South Africa part of this is deflected and sent northwards along the west coast as the cold *Benguela current*, which rejoins the equatorial. In the central parts of the two high-pressure areas there is practically no surface circulation. In the North Atlantic this region is covered by enormous banks of gulf-weed (*Sargassum bucciferum*), hence the name Sargasso Sea. The Sargasso Sea is bounded, roughly, by the lines of 20°-35° N. lat. and 40°-75° W. long.

The sub-surface circulation in the Atlantic may be regarded as consisting of two parts. Where water is banked up against the land, as by the equatorial and Gulf Stream drift currents, it appears to penetrate to very considerable depths; the escaping stream currents are at first of great vertical thickness, and part of the water at their sources has a downward movement. In the case of the Gulf Stream, which is not much impeded by the land, this descending motion is relatively slight, being perhaps largely due to the greater specific gravity of the water; it ceases to be perceptible beyond about 500 fathoms. On the European-African side the descending movement is more marked, because the coast-line is much more irregular, and the northward current is deflected against it by the earth's rotation; here the movement is traceable to at least 1000 fathoms. The northward movement of water across the Norwegian Sea extends down from the surface to the Iceland-Shetland ridge, where it is sharply cut off; the lower levels of the Norwegian Sea are filled with ice-cold Arctic water, close down to the ridge. The south-moving currents originating from melting ice are probably quite shallow. The second part of the circulation in the depth is the slow "creep" of water of very low temperature along the bottom. The North Atlantic being altogether cut off from the Arctic regions, and the vertical circulation being active, this movement is practically non-existent; but in the South Atlantic, where communication with the Southern Ocean is perfectly open, Antarctic water can be traced to the equator, and even beyond.

The tides of the Atlantic Ocean are of great complexity. The tidal wave of the Southern Ocean, which sweeps uninterruptedly round the globe from east to west, generates a secondary wave between Africa and South America, which travels north at a rate dependent only on the depth of the ocean. With this "free" wave is combined a "forced wave," generated, by the direct action of the sun and moon, within the Atlantic area itself. Nothing is known about the relative importance of these two waves. (H. N. D.)

Atlas Mountains.—Since the exploration of the western section by Hooker and Ball in 1878, this range has been visited and even crossed at more than one point by later travellers. Oscar Lenz, who surveyed a considerable part of the Great Atlas north of Tarudant, and determined a pass south of Ihr in the Little Atlas in 1879-80, and penetrated thence across the Sahara southwards to Timbuktu, was followed in 1883-84 by Ch. de Foucauld, whose extensive itineraries include many districts that had never before been visited by any Europeans. Such were parts of the first and middle ranges crossed once; three routes over the Great Atlas, which was moreover traversed along both flanks nearly for its whole length; and six journeys across the Little Atlas, with a general survey of the foot of this range and several passages over the Jebel-Bani. Then came the late Joseph Thomson, who explored some of the central parts, but broke little new ground, and failed to cross the main range (1888); H. M. P. de la Martinière, who increased our knowledge of the uplands in the province of Fez (1890-91); and lastly, Walter B. Harris, who explored some of the southern slopes and crossed the Little Atlas during his expedition to the Tafilet oasis (1894). Thanks to these expeditions, and especially to De Foucauld's careful surveys, we now possess a somewhat clear idea of the hitherto imperfectly known Atlas system in its more important western (Moroccan) section, which bears the comprehensive Berber name of ADRAR N'DEREN, the "Deren Mountains." Here it forms not two or three chains, as hitherto supposed, but as many as five distinct ranges, all varying in length and height, but disposed parallel to one another in the normal direction from south-west to north-east, with a slight curvature towards the Sahara. Generally speaking, the northern more or less convex slopes, being exposed to the moist Atlantic winds, are in many places well wooded, while the southern flanks, which intercept the dry Saharan winds, are mainly destitute of vegetation.

The Great Atlas.

The main range, commonly known as the GREAT ATLAS, occupies a central position in the system, and is by far the longest and loftiest chain, terminating, not in a plateau as often asserted, but in a sharply outlined crest, and culminating between the Bibawán Pass and the Jebel Aïshin. The fall towards the Dahra district at the north-east end is gradual and continuous, but precipitous at the opposite extremity facing the Atlantic between Agadir and Mogador. At several points the crest has been deeply eroded by old glaciers and running waters, and thus have been formed a number of passes, which, however, are little utilized for peaceful intercourse, the approaches on both slopes being mostly held and blocked rather than kept open by mutually hostile Berber tribes. The Aïshin section, culminating in a peak nearly 15,000 feet high, maintains a mean altitude of 11,600 feet, and from this great mass of schists and sandstones a number of secondary ridges radiate in all directions, forming divides between the Um-er-Rébia, the Sebu, the Muluya, the Ghir, and the Draa, which flow respectively to the west, north-west, north-east, south-east and south. Eastwards the Aïshin terminates abruptly in the steep Jebel-Terneït cliffs, which rise some 6000 feet above the surrounding plains. For a distance of 100 miles it nowhere presents any passes accessible to caravans; but south-westwards some gaps in the range afford communication between the Um-er-Rébia and the Draa basins. In the same direction the Aïshin is continued by a not yet named crest, which appears to maintain the same mean altitude of considerably over 11,000 feet, and it is this south-western extension of the Moroccan system which gives it greater average height than the European Alps, although dominated by less elevated peaks. Yet a few summits in the extreme south-west still exceed 11,000 feet in the neighbourhood of Cape Ghir. Besides huge masses of old schists and sandstones, geologists have discovered extensive limestone, marble, diorite, basalt, and porphyry formations, while granite prevails on the southern slopes of the Aïshin range. The presence of enormous glaciers in the Ice Age is attested by the moraines at the Atlantic end, and by other indications farther east. The best known passes are: (1) The Bibawán in the upper Wed-Sus basin (4150 feet according to Lenz); (2) the Tizi, *i.e.*, the "Pass" in a pre-eminent sense, giving access from Marakesh to Tarudant, rugged and difficult, but low, and utilized by Lemprière, Jackson, Lenz, and other travellers; (3) Tizi n'Tameffut, leading down to the Draa valley; (4) Tizi n'Glawi (7600 feet, Foucauld); (5) Tizi n'Telremt (7250 feet, Foucauld), leading down to the Wed-Ghir.

The Secondary Ranges.

The MIDDLE ATLAS, skirting the north flank of the Great Atlas at some distance inland, is not visible from the coast, and is still but little known; but seems to run from the region north of Demnat to the Dahra district beyond Debdon, presents a somewhat regular snowy crest between the Um-er-Rébia and the Wed el-Abid valleys, and is crossed by passes from 5000 to 6000 feet high. Both slopes are wooded, and its forests are the only parts of Morocco where the lion still survives.

The **Little** or **Anti-Atlas** running parallel to and south of the main range is one of the least elevated chains in the system, having a mean altitude of not more than 5000 feet, although some peaks and even passes exceed 6000 feet. At one point it is pierced by a gap scarcely five paces wide with polished walls of variegated marbles. Although in some winters nearly free from snow, La Martinière found the Little Atlas quite covered with a white mantle in 1890-91. The Atlas system is completed by two other less important ranges — the **Jebel-Bani**, south of the Little Atlas, crossed several times by Foucauld, who describes it as a low, narrow rocky ridge with a height of 3000 feet in its central parts; and the **Ulmess Riata**, south of the middle range, not a continuous range, but a series of broken mountain masses from 3000 to 3500 feet high, and traversed by the rivers Sebu and Muluya.

Authorities.—Thomson, Joseph. *Travels in the Atlas and Southern Morocco.* London, 1889.—Lenz, Dr Oscar. *Timbuktu.* Leipzig, 1884.—De Foucauld, Vicomte Ch. *Reconnaissance au Maroc*, 1883-84, Paris, 1888. — Martinière, H. M. P. de la. *Morocco; Journeys to the Kingdom of Fez, &c.* London, 1889.—Harris, Walter B. *Tafilet, a Journey of Exploration in the Atlas Mountains, &c.* London, 1895. (A. H. K.)

ATMOSPHERIC ELECTRICITY.

§ 1. **Investigation** into the early history of atmospheric electricity would be the province rather of the antiquary than of the scientific man. In pre-scientific days lightning was usually regarded as the special vehicle of divine vengeance. Lucretius was perhaps the first who attempted to apply to its elucidation the scientific method; he pointed out that even temples of Jupiter had not escaped the thunderbolt, which seemed to imply an incredible degree of inefficiency in the department over which that divinity was supposed to preside. Like most modern scientific men who have considered the subject, Lucretius had a theory of his own, and he might almost be looked upon as the parent of the "electric fluid" phraseology still so prominent in popular writings. Even in 1749, when Franklin proposed the famous kite experiment to test the identity of natural and artificial electricity, the electric fluid theory was probably held by most scientific men in a fairly literal sense. The electric fluid was supposed to reside in the clouds, whence it was attracted by any sharp point held upwards. Shortly after 1750 the observations by Lemonnier and others of electric phenomena in the atmosphere in the absence of cloud led to some modification of ideas. It was only, however, with the introduction of improved methods and apparatus after the middle of the 19th century, mainly by Lord Kelvin, that there was any approach to exact measurements of atmospheric electricity. To understand the different methods employed or recommended, a brief survey of the phenomena is necessary.

§ 2. At most places in dry weather the electric potential near the ground is normally positive relative to the earth, and increases with the height. The existence of earth currents shows that the earth, strictly speaking, may not be all at one potential; but the potential differences between points on the earth's surface—say, 1 kilometre apart—are insignificant compared to the normal potential difference between the earth and a point 1 metre above it, and when considering this latter difference we may regard the earth as at a uniform zero potential. What is aimed at in ordinary observations of atmospheric electricity is the measurement of the potential difference between the earth and a point at a given height above it, or else the difference in potential between two points in the same vertical at a given distance apart.

Instruments.

Let a conductor—say, a metallic sphere—be supported by a metal rod of negligible capacity whose other end is earthed. Then the conductor must all be at zero potential, and consequently the sphere must have an induced charge which produces at its centre a potential equal, but opposite, to what would exist at the same spot in free air. This neglects any charge carried by the air displaced by the sphere, and assumes a statical state of conditions, and further, what in practice is never wholly realized, that the conductor exerts no disturbing influence outside itself. Suppose now that the sphere's earth connexion is broken, and that it is carried by an insulating handle inside a building at zero potential, where its potential (relative to the earth) is determined. If this potential is − V (volts), then, assuming no loss of electricity during the operations, the potential of the air at the spot occupied by the sphere was + V. This method under various forms was largely in use about the middle of the 19th century. It was followed for many years by Quetelet at Brussels, and in a modified form by Palmieri at Naples; in recent years it has been employed at the suggestion of Elster and Geitel on the top of the Sonnblick.

Next, suppose that a fixed conductor is insulated from the ground, and that by some means it is kept at the potential of the air which it displaces, then the measurement of its potential is equivalent to a measurement of the potential of the air. This is the basis of various seemingly different methods. Originally the conductor took the shape of long metal wires, supported by silk or other insulating material, and no artificial means were employed to bring them to the potential of the surrounding air. The addition of sharp points was a step in advance. But the method can hardly be said to have been a quantitative one until the sharp points were replaced by either a flame (fuse, gas, lamp) or a liquid jet breaking into drops. In either case the theory is the same. The matter leaving the conductor, whether it be the products of combustion of a fuse or the drops of a liquid, supplies the means of maintaining equality of potential between the conductor and the air at the spot where the matter quits electrical connexion with the conductor. It is customary to apply the term *collector* to the flame or liquid apparatus, its function being, in popular language, to collect electricity.

§ 3. Several forms of flame-collector have been proposed, and two have been a good deal used, viz., Lord Kelvin's portable electrometer (*Papers on Electrostatics and Magnetism*, §§ 263, 277, &c.) with a fuse, and Exner's form of gold-leaf electroscope (Exner, *Wien. Sitz.* vol. xciii. (Ab. ii.), 1886, p. 222; also *Sitz.* xcv., xcviii., xcix., &c.; Elster and Geitel, *Terrestrial Magnetism*, vol. iv. p. 15, &c.) in conjunction with an oil lamp or gas flame. The latter is the instrument employed in most of the recent work done by Exner, Elster and Geitel, and others in Austria and Germany. The most obvious defect of the ordinary flame-collector is the tendency in the flame to be blown out. This prevents the use of Exner's form on windy days, but Pellat (*Soc. Franc. Phys. Bull.* June 1899; *Science Abstracts*, 1706, for 1899) has invented a form which claims to have surmounted this difficulty.

Of liquid collectors the representative is Lord Kelvin's "water-dropper." The water is contained in a tank standing on insulated supports, and the tube through which the jet issues passes through a hole in a window. From the tube, or the tank, an insulated wire passes to a quadrant electrometer. Readings can be taken by eye, or a continuous photographic record can be obtained. In the latter case, light reflected from the mirror attached to the electrometer needle falls on prepared paper, which is wound round a drum driven by clockwork. Installations of this kind are, or have been, in operation at a good many observatories, including Kew, Greenwich, Lyons, Perpignan, Lisbon, and Batavia; of late years a water-dropper has been in operation during summer near the top of the Eiffel Tower. At Kew Observatory the water-dropper tube is connected to the needle of the electrometer, whose quadrants are connected, the one pair to the positive pole the other pair to the negative pole of a battery of cells, whose centre is earthed. The arrangement is shown diagrammatically in Fig. 1. The most obvious weak point in a water-dropper is the tendency to freeze in cold weather. To remedy this, less easily frozen liquids have sometimes been employed, or the water has been heated or the tube protected. By such means water-droppers were kept in continual operation at two of the stations (Sodankylä and Cape Thorsden) of the international polar year 1882-83 during very severe cold.

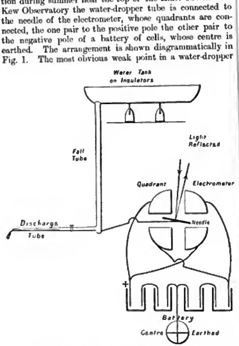


Fig. 1.—Diagram of the Water-dropper at Kew Observatory.

§ 4. Before passing to the observational data it is expedient to refer to various sources of uncertainty. As already stated, we may in this inquiry regard the earth as at a uniform zero potential. Above a limited area of a level plain of absolutely smooth surface, devoid of houses, trees, or grass, the equipotential surfaces under normal conditions would be horizontal planes, and if we could determine the potential at a point 1 metre above the ground we should have a definite measure of the *potential gradient* at the earth's surface. The presence, however, of apparatus or observers upsets the conditions, while above uneven ground, or near a tree or a building, the equipotential surfaces cease to be horizontal. In an ordinarily moist climate a building seems to be practically at the earth's potential; near its walls the equipotential surfaces are far from being horizontal, and near a ridge they may lie very close together. The height of the walls in the various observatories possessing water-droppers, the height of the water-dropper tube above the ground, and the distance it projects from the wall, all vary largely. Again, the tube may project from the centre of a long wall or from a corner, and there may be external buildings or trees sufficiently near to influence the potential. An interesting example of the influence of the situation is presented by Batavia Observatory. During the years 1887-90, with the water-dropper at a height of 2 metres above the ground, the mean of the potentials recorded was 79 volts; but during 1890-95, with the water-dropper at a height of 7·8 metres, the mean voltage was 967. This will show the futility of comparing the *absolute* voltages met with at two stations, unless means exist of allowing for the difference in the environments of the apparatus. This is the principal reason why Tables I. and II., p. 775, give the *ratios* borne by individual hourly or monthly values to the mean value for the day or year.

§ 5. There are other sources of uncertainty. If the shape of the equipotential surfaces near the jet is influenced by trees, shrubs, or grass, the influence will vary throughout the year. Again, in winter, the varying depth of snow or the formation of icicles may exert an appreciable influence. There are further sources of trouble in the apparatus itself. Unless the insulation is perfect, the potential recorded is not that of the atmosphere at the spot where the jet breaks. The action of the jet is opposed by the leakage through imperfect insulation, and if this is greater at one hour of the day, or at one season of the year than at another, there may be a fictitious element in the diurnal or annual variation. A similar result may arise from variability in the pressure under which the jet issues, especially if the insulation is indifferent. The potentials that have to be dealt with are often hundreds, and sometimes thousands, of volts, and insulation troubles are more serious than is generally appreciated. As a check on the records from water-droppers, it is desirable that scale-value determinations should be regularly made, and that the curve readings should from time to time be compared with eye observations, taken with a portable electrometer or electroscope in a fixed position, at a sufficient distance from buildings or shrubs. In interpreting the records from a water-dropper, allowance must be made for the existence of purely local phenomena. The necessity for this was shown as long ago as 1860 at Glasgow (Kelvin, *Papers on Electrostatics and Magnetism*, § 392). Two water-droppers were kept running in the university buildings, at no great distance apart but at different levels, and it was found that they often did not show pronounced changes of potential simultaneously. From this Lord Kelvin drew the conclusion—which more recent observations have only tended to confirm—that there are often electrified portions of the atmosphere in motion close to the earth. What may be regarded as accidental temporary disturbances have probably little influence on the results found for mean diurnal or annual inequalities, but this is not the case with influences such as the site of the station, whether in a valley or on a hill, near a river or the sea.

Variations of potential.

§ 6. When rain is falling the potential frequently changes rapidly. These changes are often too sudden to be satisfactorily dealt with by an ordinary electrometer, and they sometimes leave hardly a trace on the photographic paper. Again, the rain dripping from all parts of the efflux tube may materially affect the situation. For these and other reasons, it is customary at some observatories to take no account of days on which there is an appreciable amount of rainfall, or else to form separate tables for "dry" or "fine" days, and for "all" days. In other cases negative potentials are excluded from certain of the tables. Speaking generally, the exclusion of days of rain and of negative potential comes pretty much to the same thing (see, however, § 15).

Of the accompanying tables (p. 775) the first gives the mean diurnal inequality at various stations for the whole year, while the second shows diurnal inequalities for "winter" and "summer." These each include six months, except at Sodankylä and Perpignan, when three months at mid-winter and three at midsummer are meant. For reasons already stated in § 4, the hourly values are expressed as percentages of the mean value for the twenty-four hours. The height *h* of the efflux tube above the ground, and the distance *l* which it projects from the building, are in metres. The hours are in most cases mean local time. In the case of Florence, however, the entry under an hour is really the mean for the previous sixty minutes. At Sodankylä apparently a correction of about twenty-seven minutes would be necessary to give local time. The data employed in calculating the tables are derived from the following sources: Cape Thorsden (*Observations faites au Cap Thorsden, Spitzberg, par l'Expédition Suédoise*, tome ii. 2, par S. A. Andrée, Stockholm, 1887); Sodankylä (*Expédition Polaire Finlandaise*, tome iii., Helsingfors, 1898); Kew Observatory (Everett, *Phil. Trans.* for 1868, p. 347, and Whipple, *Brit. Assoc. Report* for 1881, p. 443); Greenwich (annual volumes of *Greenwich Magnetical and Meteorological Observations*); Florence (*Met. Zeit.* for 1891, p. 357); Perpignan (*Met. Zeit.* for 1891, p. 113, and 1890, p. 319); Lisboa (annual volumes of *Annaes do Obs. do Infante D. Luiz*); Batavia (*Observations made at the Mag. and Met. Obs. at Batavia*, vol. xviii., 1895); Cape Horn (Hann, *Met. Zeit.* for 1889, p. 95).

§ 7. Some of the results in Table II. are shown graphically in Fig. 2, along with some corresponding

TABLE I.

Mean Diurnal Inequality for the Year.

Station.	Cape Thorsden.	Sodankylä.	Kew Observatory.			Greenwich.	Florence.	Perpignan.	Lisbon.	Batavia.		Cape Horn.
Period.	1882-83.	1882-83.	1862-64.	1880.	1880.	1893-96.	1883-85.	1886-88.	1884-86.	1887-90.	1890-95.	1882-83.
Days.	Quiet.	All.	..	All.	Pos.	All.	All.	Fine.	All.	Dry.	Dry.	Pos.
h i	3·38 1·67	3·0 2·5	3·5 1·0	3·3 1·4	3·3 1·4	3·0 1·8	? ?	3·4 1·5	3·0 0·5	2 ..	7·8 ..	3·5 3·0
Hour.												
1	97	91	67	102	101	97	92	78	84	147	125	82
2	99	65	79	95	95	89	83	72	80	141	114	73
3	94	82	74	86	86	87	77	71	76	135	109	85
4	89	84	72	85	84	66	75	72	81	128	102	61
5	93	89	71	85	84	86	74	77	63	127	101	85
6	96	91	77	88	68	92	62	92	92	137	117	95
7	94	97	92	97	95	100	100	107	101	156	147	106
8	102	100	106	97	95	102	112	114	105	104	119	118
9	98	98	107	102	101	100	113	111	104	67	82	119
10	93	102	100	90	91	101	107	100	104	42	55	123
11	98	96	90	94	96	96	100	96	102	35	46	123
Noon.	96	102	92	91	95	97	95	99	108	30	43	115
1	99	105	90	90	94	96	92	99	111	30	42	112
2	99	107	91	68	89	94	90	97	114	30	43	94
3	101	108	92	85	85	95	89	99	109	33	46	89
4	108	108	98	88	90	97	69	105	108	41	53	88
5	108	108	108	99	97	102	94	118	108	67	73	64
6	109	110	121	110	108	106	116	126	111	91	108	110
7	108	102	134	116	121	111	121	161	116	120	145	107
6	114	111	139	129	127	115	129	129	114	167	155	123
9	110	111	138	130	132	117	132	120	109	146	165	112
10	100	104	128	130	127	117	127	109	102	148	147	99
11	101	108	113	114	114	111	114	97	92	151	143	85
12	99	93	99	105	105	104	100	86	68	147	130	98
Mean value in volts.	10	65	51	87	91	...	119	55	99	79	967	100

TABLE II.

Diurnal Inequalities.

Station.	Cape Thorsden.		Sodankylä.		Kew Observatory.		Greenwich.		Perpignan.		Lisbon.		Batavia.			
Period.	1882-83.		1882-83.		1880.		1894 and 1896.		1888.		1885-86.		(2 metres.) 1887-90.		(7·3 metres.) 1890-95.	
	Jan. to April.	May to Aug.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.
Hour.																
1	97	87	90	99	94	115	87	110	68	88	76	93	145	149	124	127
2	111	83	79	81	92	104	84	101	67	80	74	86	139	142	114	114
3	118	80	78	90	84	92	76	98	62	77	75	82	137	135	109	106
4	103	76	74	99	81	90	77	96	63	81	79	81	131	127	100	103
5	103	78	74	111	80	98	78	94	68	94	77	66	162	123	102	100
6	114	78	80	114	83	97	82	101	83	112	82	96	138	136	118	118
7	108	62	86	117	91	105	94	107	102	116	98	108	166	153	152	142
8	107	98	95	122	94	100	97	111	122	111	100	105	118	92	131	93
9	92	102	91	109	106	91	98	102	125	109	106	100	74	64	91	76
10	89	102	106	101	100	(71)?	102	98	112	101	109	97	46	40	87	84
11	97	101	98	97	97	93	103	86	100	102	108	96	35	36	47	46
Noon.	98	100	98	100	100	65	107	94	106	105	113	98	31	30	42	44
1	101	104	116	97	99	85	107	85	106	98	117	107	29	33	40	42
2	96	104	113	97	94	78	109	82	106	90	116	114	28	32	40	46
3	93	110	121	93	90	75	111	76	106	68	114	104	24	41	48	50
4	92	119	111	96	97	74	116	81	111	89	115	102	30	49	50	55
5	101	112	105	106	104	65	112	98	117	93	116	101	60	74	73	73
6	98	116	115	92	114	96	114	98	126	103	120	104	66	94	108	107
7	103	124	118	102	124	111	117	99	131	111	128	106	119	122	144	146
8	102	126	117	106	129	125	118	108	126	115	115	116	138	135	153	156
9	95	126	115	90	126	144	111	118	117	119	105	115	145	147	152	157
10	86	98	112	90	120	144	110	124	104	115	98	110	148	146	148	150
11	90	103	113	103	106	130	102	120	93	106	86	97	149	152	140	148
12	102	89	95	65	97	121	93	116	80	95	75	98	148	146	126	133

results for the Bureau Central Météorologique, the Eiffel Tower, and the Collège de France, Paris, the last based on diagrams in a paper by Chauveau (*Séances de la Soc. Franc. de Physique* for 1899, p. 91). In this paper Chauveau suggests that there are at ordinary stations two distinct types of diurnal variation, viz., a summer type possessed of two distinct maxima and two distinct minima, and a winter type showing only one maximum (in the evening) and one minimum (in the morning), or else closely approaching this as an ideal. Arguing from the results on the Eiffel Tower and from those on a high staging at Trappes, Chauveau draws the conclusion that the afternoon minimum in summer arises from causes peculiar to stations near the ground, and that at moderate heights the winter type of inequality applies in all latitudes throughout the entire year. It should be remarked, however, that some of the results in Tables I. and II. hardly seem to fit this theory.

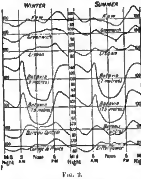


Fig. 2.

Some of the irregularities in Tables I. and II. would probably disappear if more years' data were employed; this is especially true in cases where the range is small, as at Cape Thorsden in winter. In this instance, according to the data, the inequality is almost the opposite of that usually met with, the potential being highest in the early morning hours, and at about its lowest value between 9 and 11 P.M. In summer the morning minimum is as well marked as at other places. It will be noticed that the evening maximum is decidedly less prominent at Greenwich than at Kew, especially in winter, and that the afternoon minimum in winter is distinctly present at Kew though hardly visible at Greenwich. In considering such discrepancies it would be well to bear in mind the possibility, or rather probability, that atmospheric potential *may*, like thunderstorms and auroras, vary much from one year to the next. At Lisbon the summer inequality presents three fairly equal maxima. These are possibly fictitious, as the range is exceptionally small, but the phenomenon was exhibited by each of the three years included, and there is a suggestion of more than two maxima at some of the other stations. Narrowness of diurnal range is clearly no general attribute of low latitudes, for that at Batavia is most conspicuous. Some of the irregularities in the tables may be due to the interaction of conflicting agencies, of which one may be dominant at one time, another at another. Thus C. R. André (*Comptes Rendus*, 112 (1891), p. 1509), on separating quiet bright days at Lyons into two sets, according as the wind was northerly or southerly, concluded that the characteristics of the diurnal inequality were conspicuously different in the two cases. André's diagrams show two well-marked maxima and minima (with small doubtful ones) in each instance, but with southerly wind the morning maximum is much the larger, whereas with the wind northerly it is somewhat the smaller.

§ 8. The mean of the hourly ordinates of electrograms (electric potential curves) for a month gives the monthly mean, and the intercomparison of the monthly means gives the annual inequality. For reasons already indicated, Table III. gives relative not absolute values for the twelve monthly means. The data are from the same sources as those utilized in Tables I. and II.

TABLE III.

Annual Inequality; Percentages of Mean Potential for the Year.

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
Cape Thorsden, 1882-83	153	86	147	209	178	63	65	79	...	...	13	7
Sodankyla, 1882-83	94	133	148	155	186	93	53	77	47	72	71	71
Kew, 1880 {all days	165	140	157	106	60	57	82	43	54	96	127	134
Kew, 1880 {pos. only	161	145	149	105	62	59	61	44	53	102	123	136
Greenwich, 1893-94, 1896	110	112	127	107	83	71	76	84	83	104	104	139
Florence, 1883-88	132	110	98	84	86	81	77	90	89	99	129	125
Perpignan, 1886-88	121	112	108	89	91	92	89	82	74	99	122	121
Lisbon, 1884-86	104	105	104	92	91	93	87	92	100	99	115	117
Batavia (2 m.), 1887-90	97	115	155	127	129	105	79	62	69	79	90	93
Batavia (7·8 m.), 1890-95	100	89	103	120	98	103	85	99	73	101	117	112

At Sodankylä the year employed began with September 1882, at Cape Thorsden with November 1882. At the latter station there were only ten months' observations, and the results for November and December seem hardly credible. The figures suggest that the rapid fall in potential observed at Kew and Greenwich in April and May takes place later in the far north, and somewhat earlier in Florence, Perpignan, and Lisbon. At the higher level at Batavia the annual inequality seems very irregular, notwithstanding that it is a mean from six years' results.

§ 9. Diurnal and annual inequalities have been published for a variety of places, which are based on eye observations with Exner's electroscope. Such results depend only on observations taken at certain hours of the day, sometimes only on bright days; consequently they are not directly comparable with inequalities based on the continuous records of self-recording instruments. Two examples are given in Table IV. The Wolfenbüttel data are due to Elster and Geitel (*Wien. Sitz.* ci. Abth. ii., 1892, p. 703); the data for Ladenburg were obtained by Gockel (*Met. Zeit.* for 1897, p. 281) during the years 1892-95. The figures are the monthly means in volts of the potential at a fixed point in the atmosphere.

TABLE IV. (*Annual Inequality*).

	Jan.	Feb.	Mch.	April.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Wolfenbüttel	391	339	294	138	110	102	123	121	121	188	260	470
Ladenburg	897	557	148	66	62	60	60	..	73	116	106	134

§ 10. Table V. gives some data bearing on the question of how the amplitude of the diurnal inequality is influenced by the height of the water-dropper above the ground. The heights are in metres, the maximum and minimum values of the potential are in volts. The data for Paris and Trappes are from the paper by Chauveau already mentioned; the others from the same sources as Tables I. and II. London is the mean of Kew (1880) and Greenwich.

TABLE V.

Station.	London.		Paris.		Trappes	Perpignan.	Batavia.	
			Bureau Central.	Eiffel Tower.				
Height	3		..	285	20	8·4	2	7·8
Season	Year.	Summer.	Summer.	Summer.	Summer.	Year.	Year.	Year.
Maximum	..	..	172	2400	272	72·3	125	1406
Minimum	..	..	102	1740	215	39·0	24	464
Max./mean	1·24	1·34	1·29	1·18	1·23	1·31	1·38	1·65
Min./mean	·85	·76	·77	·79	·70	·71	·30	·42

Perhaps all that can be said is that the results are not unfavourable to the view that the relative importance of the diurnal inequality diminishes as the height above the ground increases.

§ 11. The diurnal inequality near the ground on the top of a mountain has no necessary relationship to that above a plain at the same height above the sea. Elster and Geitel (*Met. Zeit.* for 1891, p. 321) believe that on the top of a mountain the diurnal variation is small, basing their view partly on some observations of their own on the top of the Sonnblick (3100 metres). The mean of these for certain hours of the day, along with some corresponding data obtained by Michie Smith in January 1885 on Dodabetta (8642 feet), the highest summit of the Neilgherries in India (*Trans. R.S.E.* vol. xxxii. p. 553), are given in Table VI. (afternoon hours dashed).

TABLE VI.

Hour.	6	8	10	Noon.	2'	4'	6'
Sonnblick . . .	200	218	240	214	221	...	220
Dodabetta . . .	...	55	67	93	108	93	69

The unit in which the potential is measured is not the same in the two cases, and the hours are not exact local mean time. Elster and Geitel's results, except that for 6 P.M., depend on three days' observations; Michie Smith's are means from five days nearly free from mist. In support of their view Elster and Geitel refer to a few observations by Exner on a hill near St. Gilgen, and to a considerable number of observations made more recently, but with apparently somewhat primitive apparatus, on the Sonnblick. In view of the large variation observed on Dodabetta, more experiments on the subject are clearly wanted.

§ 12. Many of the data referred to below are taken from Le Cadet's interesting book *Étude du champ électrique de l'Atmosphère*, Paris, 1898. For small heights use may be made of captive balloons, provided with a burning fuse, and carrying a wire attached to an electroscope on the ground. With such apparatus Exner (*Wien. Sitz.* xciii., 1886, p. 222) found the potential gradient nearly uniform up to heights of 30 or 50 metres above the ground. At great heights the potential differs so much from that of the earth that captive balloons are unsuitable. Accordingly, in 1885 a free balloon ascent was made at Vienna by Lecher, at Exner's suggestion. The potential gradient was found by using two water-droppers, with their jets at a difference of 2 metres in level. The mean of the few measurements taken made the potential gradient at a height of 550 metres nearly double that at the ground. More recent experiments, however, tend to show that Lecher's observations, if correct, were exceptional. Perhaps the most important of these experiments are those due to Le Cadet himself. Like Lecher he employed two collectors—either water-droppers or flame-collectors—but usually with an arrangement for altering their difference of level. Table VII. gives some of Le Cadet's results. Each value is usually the mean of a series of readings. H is the height of the balloon in metres, P the potential gradient in volts per metre.

TABLE VII.

Balloon Observations by Le Cadet.

Date.											
Aug. 1, 1893.	H	615	740	790	870	1005	1100	1150	1300	..	..
	P	75	45	35	26	29	27	38	33	..	..
Aug. 9, 1893.	H	824	830	1060	1255	1290	1745	1940	2080	2310	2520
	P	37	41	43	41	42	34	25	21	18	16
Sept. 11, 1897.	H	1140	1378	1630	1914	2370	2786	3136	3304	3912	4085
	P	42·0	38·0	32·6	25·3	21·7	21·2	18·8	18·7	13·6	13·2

On 11th September the value found for P at the ground was 150. The marked tendency shown in the table for P to diminish as the height increases is equally prominent in other observations by Le Cadet. Thus on 24th March 1897, at heights between 1680 and 2300 metres, P varied from 32 to 28, while its mean value at the ground as deduced from the simultaneous records of the Lyons water-dropper was 99. Similar results were observed in Germany by Baschin, during an ascent on 17th February 1894. Using two "water-droppers"—with 65 per cent. alcohol in the water—he found for P values of 19, 28, and 13, answering to the heights of 760, 2400, and 2800 metres respectively. During the ascent the value of P at the ground varied from 98 to 181 at Potsdam, and from 85 to 200 at Wolfenbüttel. In opposition to these results Tuma, during an ascent at Vienna in 1892, found P to increase as the height increased from 410 to 1900 metres; but several recent ascents (*Met. Zeit.* for 1899, p. 280, or *Wien. Sitz.*, March 1899) lead him to the same conclusion as Le Cadet, viz., that under normal conditions the potential gradient diminishes as the height increases. The possibility that a free balloon may carry off a charge as it leaves the earth has been discussed by Bornstein (*Met. Zeit.*, 1898, p. 65), who shows how such a charge could be measured if the balloon carried three water-droppers at different levels. Supposing however a charge to exist initially, it would tend, as Baschin points out, to disappear when ballast was discharged. Tuma, from experiments made on several of his recent ascents, concluded that no charge existed on the balloon.

§ 13. If V be the potential, ρ the density of free electricity at a point in the atmosphere, at a distance r from the earth's centre, we have, neglecting variations of V in horizontal directions, $r^{-2}(d/dr)(r^2dV/dr)+4\pi\rho=0$.

Throughout the limited portion of the earth's atmosphere open to experiment, we may for practical purposes treat r^2 as constant in this equation, and so take $\rho=-(1/4\pi)(d/dr)(dV/dr)$. Thus ρ is positive if, as recent experiments seem to show, the potential gradient, dV/dr, diminishes as we recede from the earth.

If σ be the surface density of the charge on the earth, we have $\sigma=-(1/4\pi)(dV/dr)$ where dV/dr is the potential gradient close to the ground. As dV/dr is normally positive, the inference is that normally the earth's surface has a negative charge.

If we take a tube of force 1 cm. cross-section, and suppose it cut by the equipotential surfaces at the heights h_1 and h_2 above the ground, then under the conditions assumed above the total charge, M, included within the specified portion of the tube is given by

$$4\pi M=(dV/dr)_{r=R+h_1}-(dV/dr)_{r=R+h_2},$$

where R is the earth's radius.

Le Cadet applies equivalent formulæ to his balloon ascent of 11th September 1897, assuming the potential gradient to be 150 (volt/metre) at the ground, and 13·4 (volt/metre) at 4000 metres. Supposing a volt equal to ·0033 C.G.S. electrostatic units, the charge on the ground per sq. cm. is $-(150/100)\times{\cdot}0033\div4\pi$, or approximately $-{\cdot}000395$ electrostatic unit (in coulombs -13×10^{-14}). The charge in the unit tube of force between the ground and the height of 4000 metres works out at $+{\cdot}00036$ C.G.S. electrostatic unit, leaving only about $+{\cdot}000035$ electrostatic units above this level. These figures give for the average density of the charge between the height of 4 kilometres and the ground the value 9×10^{-10} electrostatic units (3×10^{-19} coulombs). This is insignificant compared with the density of the charges recently given to air by Kelvin, Maclean, and Galt (see § 17). Trabert (*Met. Zeit.*, 1898, p. 401) makes a similar calculation in discussing the probability of the existence of vertical earth-air currents of the order 17×10^{-12} amperes per sq. cm. The existence of such currents seems indicated by the researches of A. Schmidt and others, who have concluded that a portion of the earth's magnetic field cannot be accounted for by a Gaussian potential (see MAGNETISM, TERRESTRIAL, § 24). Trabert takes 130 (volt/metre) as the most probable mean value of the potential gradient at the ground. Answering to this, a calculation similar to Le Cadet's makes the surface density -11×10^{-14} coulombs per sq. cm. Thus Schmidt's hypothetical mean current would transmit in one second fully 150 times as much electricity as exists at the instant on the earth's surface. This would imply a rate of dissipation about one million times larger than that found by Linss and by Elster and Geitel in the absence of photo-electric action (see § 18).

§ 14. Elster and Geitel have attempted to measure the charge brought down by rain falling into an insulated vessel, as well as the simultaneous potential gradient in the atmosphere (*Met. Zeit.*, 1888, p. 95; *Wien. Sitz.* xcix. Abth. ii., 1890, p. 421; *Terrestrial Magnetism*, March 1899, p. 15). There are various serious difficulties—splashing of rain-drops, influence of apparatus, surgings in the electrometer, &c.—and though Elster and Geitel have done their best to surmount these, they seem somewhat doubtful of their complete success. The conclusions indicated by the experiments are: (1) raindrops almost invariably carry a charge; the sign may be positive or negative, and may change repeatedly in the course of a single rainstorm; (2) the charge is more often than not opposite in sign to the simultaneous value of the potential gradient near the ground. On 11th May 1892, during a thunderstorm, the charge brought down by the rain, when greatest, was approximately at the rate of 76×10^{-14} coulombs per second per sq. cm. of earth's surface. This was the maximum met with. In their paper in *Terrestrial Magnetism*, Elster and Geitel give graphical illustrations of their results.

§ 15. At most stations a negative potential gradient is exceptional, except during rain or fog. During rain it is a frequent but by no means invariable phenomenon, and it seldom persists long without a recurrence to positive. The alternations of sign during heavy thunderstorm rain are often both frequent and sudden, and a similar phenomenon is not unusually observed during thick fog. In some localities a negative potential gradient seems by no means uncommon, even on bright calm days. Thus Michie Smith (*Phil. Mag.* vol. xx. 1885, p. 456) observed numerous instances of negative potential at Madras during bright days in August and September. The phenomenon was quite common between 9.30 A.M. and noon, during westerly winds, which at Madras are very dry and usually dusty. The presence of dust seemed to Michie Smith a contributory cause, but dust in easterly winds was not accompanied by negative potential. At the Finnish polar station Sodankylä, in 1882-83, Lemstrom and Biese found that out of 255 observed occurrences of negative potential, 106 took place in the absence of rain or snow. The proportion of occurrences of negative potential under a clear sky was much above its average in autumn, and much below its average in spring and summer. In many cases Lemstrom and Biese observed no change of sign to follow on rain or snowfall. At Polhem, in Spitzbergen, Wijkander is reported to have observed negative potentials almost as often as positive; but the potential gradients at Polhem seem to have been abnormally low. At the polar station Godthaab, in 1882-83, negative potential seemed sometimes to be associated with aurora (Paulsen, *Bull. de l'Acad. . . . de Danemarke*, 1894, p. 148).

§ 16. It has been found by Lenard, Elster, and Geitel and others, that the potential gradient is negative near a waterfall. The influence may extend to a considerable distance. Lenard (*Wied. Ann.* xlvi. 1892, p. 584), who has specially investigated the matter, concludes that when pure water falls upon water the *air* in the neighbourhood becomes negatively charged; the presence of dust in the air is, he believes, unessential. The effect can be produced inside a closed space (Maclean and Goto, *Phil. Mag.* vol. xxx. 1890, p. 148), but under such circumstances the presence of dust seems to increase the effect. A little impurity in the water markedly diminishes the charge, and may alter its sign. More recent experiments by Kelvin, Maclean, and Galt (*Phil. Trans.* vol. cxci. A, p. 187) have shown that when air is charged by dropping water, as in Maclean and Goto's experiments, the charge is considerably greater in the air near the level of impact of the falling water than in that at a higher level. A sensible charge still remained, however, when the influence of the splashing was eliminated. In the opinion of Kelvin, Maclean, and Galt, this property of falling water renders an ordinary water-dropper unsuitable for use indoors, at least in a small room, though it constitutes no practical objection to its use out of doors. Exner (*Wien. Sitz.* (2) 1896, p. 467) observed an electrical action in the case of breaking sea-waves, noticing the spray to be negatively electrified.

§ 17. Electrification is generally admitted to exist in the atmosphere, but some authorities have held that it is carried by dust, or by ice and water particles forming clouds. Lord Kelvin's view is that ordinary air, whether containing dust or not, can be electrified, either positively or negatively. This conclusion is supported by experiments by Kelvin and Maclean (*Proc. Roy. Soc.* vol. lvi. 1894, p. 84; *Phil. Mag.* August 1894), and by more recent experiments by Kelvin, Maclean, and Galt (*Phil. Trans.* cxci. A, p. 187). In the earlier experiments the electrification was measured by means of a water-dropper. In the more recent ones, for the reasons specified in § 16, other methods were employed, and by means of needle points attached to an electric machine a charge of density 37×10^{-5} C.G.S. electrostatic units was given on one occasion to ordinary air, while a density as great as 22×10^{-4} units was attained by means of an electrified hydrogen flame. After stopping the electric machine, the electrification gradually disappeared, but could be detected for many minutes. In the earlier experiments little difference was observed between very dusty air and air as dustless as possible. Negative electrification seemed to disappear, when the machine was stopped, more rapidly than positive. In the later experiments it was found possible to give a small electrification to air in other ways, *e.g.*, by shaking it up with water or solutions of various kinds, or blowing it in bubbles through water or aqueous solutions.

§ 18. Linss (*Met. Zeit.* 1887, p. 352) found that an insulated paste-board cylinder, covered with tinfoil and charged either positively or negatively, lost its charge gradually when in the free atmosphere. The potential V existing after dissipation during time *t* was connected with the original potential V_0 by a formula of the type $V = V_0 e^{-qt}$, where *q* though constant on a particular occasion varied appreciably from day to day. The formula implies that the rate of fall of the potential varies as its existing value (counting the earth's potential as zero). Linss's experiments have been repeated by Elster and Geitel (*Terrestrial Magnetism*, vol. iv. 1899, p. 213). Their dissipator consisted of a hollow cylinder of blackened copper, insensitive to any direct photo-electric effect. When used out of doors, it was protected from rain, wind, and direct sunlight by an insulated hood. Regular daily observations were made for a long time, the loss during a given interval being measured for both positive and negative charges. In addition to numerous experiments at Wolfenbüttel, a considerable number were made on the Brocken and on the Alps, near Zermatt. Elster and Geitel denote the fraction of the charge lost per minute by E, distinguishing the sign of the charge by the addition of + or −. In the lowlands they found on the average $E\pm = 1{\cdot}3$ per cent. In other words, positive and negative charges were lost, on the whole, equally fast, and on the average a charge of 100 units lost 1·3 units in one minute. This result agrees pretty well with that obtained by Linss. Neither wind nor mist was found to possess much influence, and, somewhat contrary to expectation, the most rapid loss of charge was observed on days when the air was specially clear and free from dust. In mountainous districts they found a change in the phenomena, as may be seen from the following typical results, obtained during the ascent of a peak near Zermatt:—

Position.	Height above Sea.	E(+).	E(−).
	Metres.	Per cent.	Per cent.
Zermatt valley . .	1620	4·5	4·4
On level ground . .	2600	4·4	6·8
Near end of ridge. .	3000	2·7	7·0
Peak, Gorner Gratz .	3140	0·7	6·6

From these and similar observations Elster and Geitel conclude: (1) that normally in valleys high above the sea the rate of dissipation is greater than near sea-level, whilst remaining independent of the sign of the charge; (2) that on mountains, especially near peaks, a negative charge is lost much more rapidly than a positive charge.

A diametrically opposite phenomenon was observed by them near waterfalls. For instance, near a fall at Zermatt they obtained 16·2 per cent. for E(+) as against 1·9 per cent. for E(−).

They attribute the loss of charge to the existence of small positively and negatively charged masses in the atmosphere. In the lowlands or in mountain valleys the two species are equally numerous on the average, but positive masses largely predominate near mountain peaks and negative masses near waterfalls (cf. § 16).

§ 19. It has long been a disputed question whether vapour from a charged liquid carries off part of the charge; it is rather a vital point in some theories respecting atmospheric electricity, such as that of Exner. Various experimenters (*e.g.*, Blake, Mascart, Sohncke, Pellat) have advanced what they regarded as crucial evidence in favour of one view or the other. The question is discussed by J. J. Thomson, in his *Recent Researches in Electricity and Magnetism*, p. 54, and Trabert has treated it more recently in the *Met. Zeit.* for 1899, p. 377. Several supporters of the view that the vapour carries off a charge, *e.g.*, Lord Kelvin (*Proc. Roy. Soc.* 31st May 1894, p. 84), have pointed out that if it be conceded that a drop of pure water can be charged and evaporated, the charge must be carried off by something which is either aqueous vapour or is unknown to science.

§ 20. In Exner's theory of atmospheric electricity aqueous vapour is the essential element. If, as before, P be the potential gradient in volts per metre, and *q* be the density of aqueous vapour present in the atmosphere, then, according to Exner, $P = A/(1 + kq)$, where A and *k* are constants. In its extreme form the theory would imply that the above formula applied with A and *k* absolute constants in the case of every recorded value of P on clear days. Elster and Geitel, however, in their applications of the formula, seem generally to regard P and *q* as answering to the mean values during a day's observations. On other occasions they have attributed to A values differing from one series of experiments to another. Exner himself (*Wien. Sitz.* xcix. Abth. ii. 1891, p. 601) has applied his formula with $A = 1400$ and $k = 1{\cdot}15$ to observations at Vienna, Wolfenbuttel, St Gilgen, and India. Arranging his observations in groups, each of which answers to a narrow range of vapour density, he compares the mean observed and calculated values of P for the several groups. The tendency for the mean P to be small when the mean q is large is decided. Elster and Geitel (*Wien. Sitz.* ci. 1892, p. 703) applied Exner's formula to groups of observations made by them at Wolfenbuttel on quiet, comparatively clear days. They found a fair general agreement between the observed and calculated mean values of P for the groups, but within the same vapour density group the individually observed values of P often differed conspicuously. This had been noticed previously by Exner himself. Independent critical examinations of Exner's theory have been made by Chree (*Proc. Roy. Soc.* vol. lx. 1896, p. 96), Braun (review *Met. Zeit.* 1896, p. [78]), Trabert (*Met. Zeit.* 1897, p. 106), and Gockel (*Met. Zeit.* 1897, p. 281), dealing respectively with observations at Kew, Bamberg, Meiningen, and Ladenburg. In each case the conclusion reached was that the relation between potential gradient and vapour density is not a unique and fundamental one, as Exner supposes. When observations taken at all seasons of the year are combined together, the great majority of instances of large vapour density (or of high temperature) will be found to have occurred in summer, when the potential gradient is normally low; thus there can hardly fail to be a certain amount of agreement between observation and any theory which associates low potential with high vapour density (or high temperature).

Ultra-violet light.

§ 21. In 1887 Hertz (*Wied. Ann.* xxxi. p. 983) found that the discharge between two poles was facilitated by the presence of ultra-violet light. Subsequent experimenters (see J. J. Thomson's *Recent Researches in Electricity*, arts. 39 to 42) found that the seat of this action was the cathode, and further, that various metallic substances—notably freshly-polished zinc—when insulated became positively electrified, or rapidly lost a negative charge when exposed to ultra-violet light from any source, including the sun. This species of dissipation is confined to negative charges, and depends principally on the material of the charged surface and the freshness of its polish; but it also depends on the nature of the surrounding gas and its pressure. The property, though prominent in potassium, sodium, and zinc, is inconspicuous in most common materials at the earth's surface; Elster and Geitel, however (*Wied. Ann.* xliv. 1891, p. 722), found sensible traces of it in fluorspar and a few other minerals. The earliest recognition of ultra-violet light as a possibly important factor in atmospheric electricity, seems due to Arrhenius (*Met. Zeit.* 1888, pp. 297 and 348). Whilst mentioning the possible effect of ultra-violet light incident on the earth or on particles in the atmosphere, he relies mainly on its making the air it traverses conduct electrolytically. Elster and Geitel, on the other hand, attach main if not exclusive importance to its action at the earth's surface. From experiments with electric light they concluded that e, the rate of loss of a negative charge by a small sphere of freshly amalgamated zinc, was connected with J, the intensity of ultra-violet light, by a linear relation $e = a + bJ$ (*Wien. Sitz.* ci. Abth. ii. 1892, p. 703). Having found a and b experimentally, they determined J from day to day from the observed rates of loss of charge in sunshine. They tried several formulæ connecting J with the potential gradient P, the simplest being of the type $P = A/(\alpha + \beta J)$, where A, α, β, are constants. In comparing observed and calculated values of P, they followed Exner's example, arranging the observations in groups according to the value of J. Whilst some of the series of observed and calculated mean group values show a surprisingly good agreement, individual observations within the same group often differ conspicuously. More recently Brillouin and Buisson (reviewed *Met. Zeit.* 1898, p. 38) have found that dry ice is sensitive to ultra-violet light, the influence being of the order of one-tenth of that observed with zinc. As the ice surface melts, the effect rapidly diminishes, becoming vanishingly small when a complete layer of water has formed. This discovery has been questioned by Beundorf. If confirmed, it would increase the probability that ultra-violet light plays an important part in atmospheric electricity.

§ 22. Recently, owing mainly to the researches of C. T. R. Wilson, evidence has accumulated as to the existence in atmospheric air of nuclei—other than dust particles—which act as centres of condensation for water vapour, when supersaturation is produced artificially. Wilson found that ions acting as nuclei can be called into existence by Röntgen rays, Uranium rays, and ultra-violet light acting on negatively charged zinc or even on moist air. J. J. Thomson (*Phil. Mag.* Dec. 1898, p. 533) pointed out that if the positive and negative ions should differ in their power of condensing water vapour, then a cloud might form round the one set of ions, and that as the cloud particles fell under gravity, electrical separation would take place. Wilson (*Phil. Trans.* cxciii. p. 289) has found that ions produced by Röntgen rays do really show this difference, negative ions serving as condensation nuclei under considerably less supersaturation than positive ions. He found, however, that the non-dust nuclei, always present in small numbers in the atmosphere, and the nuclei produced in moist air by ultra-violet light do not behave as free ions; and whilst there is considerable reason to believe that ionization develops in these nuclei in the process of supersaturation this remains to be proved. Supposing ions to act as condensation nuclei in the atmosphere, Wilson's experiments seem to indicate that this action would be chiefly limited to negative ions, and that the rain so formed would mainly carry down negative electricity. As he himself remarks, however, Elster and Geitel's experiments (§ 14) do not show any conspicuous preponderance of negative electricity in rainfall. Again, the supersaturation required before even negative ions act as condensation nuclei is considerable, and Aitken (*Nature*, March 1900, p. 514) believes that the number of dust particles usually present in the atmosphere is so large as to afford little opportunity for ions to act. Elster and Geitel on the other hand (*Terrestrial Magnetism*, vol. iv. 1899, p. 213) regard the action of ions, positive as well as negative, as in all probability a factor of importance.

§ 23. Everett (*Phil. Trans.* 1868, p. 347), in discussing the Kew atmospheric electricity results, specified certain points of resemblance between the diurnal variation and that of barometric pressure. The two elements agree in having two maxima and minima in their diurnal inequalities, and the times of their occurrence, at least at Kew, are fairly similar. Hann (*Met. Zeit.* 1889, p. 106; 1890, p. 29; 1891, p. 113) has dwelt on this resemblance in reviewing atmospheric electricity observations at various stations, and has further pointed out that the relative importance of the semi-diurnal as compared with the diurnal term in a Fourier analysis, in the case of electric potential as in that of barometric pressure, appears less in arctic than in temperate latitudes, and is greatest in tropical stations.

§ 24. In the papers mentioned in § 20, Chree, Braun, Trabert, and Gockel all describe a closer association of high potential gradient with low temperature than with low vapour density. Trabert seems almost disposed to regard this association as fundamental, in the absence presumably of disturbing causes such as rainfall. If this were the case, we ought to encounter exceptionally high potential gradients at arctic stations, especially at night in winter. At Cape Thorsden, however, so far as the recorded position of the water-dropper enables one to judge, the potential gradient was exceptionally low. At Sodankyla, Lemstrom and Biese found that the mean potential gradient for the colder half of the day was considerably less than that for the warmer half during winter and spring, and that for the year as a whole, the mean gradient during the warmer hours stood to that during the colder hours in the ratio 823 : 735. Again, while the chief maximum in the diurnal inequality of the potential gradient usually occurs after sunset, the principal minimum at many stations occurs before sunrise, when the temperature is at its lowest. Finally, whilst the diurnal inequality of the potential gradient usually shows two maxima and minima, that of temperature has normally but one.

§ 25. Observations by Elster and Geitel on 19th August 1887, and by Ludwig on 22nd January 1898 (*Met. Zeit.* 1888, p. 27, and 1899, p. 281), agreed in showing a diminution of potential gradient during the totality of a solar eclipse, followed by a smart rise after totality. These observations possess a certain significance in connexion with the ultra-violet light theory of Arrhenius, to which they seem opposed. Sudden changes of potential gradient are, however, so frequent, that much weight cannot be assigned to observations so limited in number. Observations under somewhat analogous conditions, but pointing to an opposite conclusion, are described by Gockel (*Met. Zeit.* 1899, p. 481). During several days' observations in a small oasis, El Mora near Biscra, he found a marked tendency in the potential gradient to rise rapidly just after sunset.

§ 26. Lemstrom (*Brit. Assoc. Report* for 1898, p. 808) has been experimenting since 1885 on the influence of artificial electric fields or currents on the growth of plants. The influence is, he says, in general highly beneficial; for instance, it shortens the time required by strawberries and raspberries to ripen, and increases the yield. It may, however, be injurious, especially during bright days, unless abundance of water is provided. Lemstrom believes atmospheric electricity to play an important part in the growth of vegetation in high latitudes, and he assigns a special *rôle* to the needles of fir and pine trees. E. H. Cook (*Brit. Assoc. Report* for 1898, p. 809) describes experiments somewhat similar to Lemstrom's. He observed a beneficial affect on plants grown under a pole—especially the negative pole—of a Wimshurst machine or an induction coil. Cook refers to experiments aiming at the direct utilization of atmospheric electricity.

§ 27. The beginning and ending of thunderstorms at a station are seldom very clearly defined, and the duration is very variable, so that the exact significance to be attached to figures showing the diurnal inequality of thunderstorms is open to a little uncertainty. The data in Tables VIII. and IX. are all quoted by Arrhenius (*Met. Zeit.* 1888, p. 348), except those for Edinburgh, which are from a paper by Mossman (*Trans. R. S. E.* vol. xxxix. p. 63). The data for Belgium are due to Lancaster, those for Italy to Ferrari; in the latter case only storms lasting less than three hours are included. The data for the Russian empire are due to Klossousky; they are based on ten years' observations, 1870-79. In all cases the figures represent percentages of the total number, afterncon hours are dashed.

Thunderstorms.

TABLE VIII.

Relative Diurnal frequency of Thunderstorms.

Interval.	0—2	2—4	4—6	6—8	8—10	10—12	0′—2′	2′—4′	4′—6′	6′—8′	8′—10′	10′—12′
Edinburgh	1·7	2·0	1·4	1·7	4·7	14·2	22·4	22·7	11·9	8·2	5·1	2·0
Belgium .	3·0	2·9	1·7	1·8	2·0	6·4	12·9	21·6	19·4	15·8	8·4	4·1
Italy .	1·3	1·6	1·4	2·0	3·6	8·5	19·5	26·5	16·6	9·8	8·3	1·5

TABLE IX.

Relative Diurnal frequency of Thunderstorms.

Interval.	0—3	3—6	6—9	9—12	0′—3′	3′—6′	6′—9′	9′—12′
North Russia .	...	1·9	3·6	11·3	28·3	22·6	24·5	7·6
Baltic Provinces, Finland	3·3	2·5	4·1	14·1	23·3	29·5	14·9	8·3
West Russia .	3·1	4·6	3·4	6·1	21·0	29·9	21·8	10·1
Central " .	3·1	3·1	3·3	8·7	26·6	27·5	20·8	6·9
Ural . . .	3·6	2·6	2·2	8·3	24·2	28·7	20·6	9·8
Siberia . .	2·7	3·0	2·6	9·2	25·1	28·6	18·3	10·5
Caucasus . .	4·5	1·2	0·9	4·1	14·6	31·8	28·3	14·6
South Russia .	5·5	4·9	11·6	12·9	25·6	16·6	11·7	11·0
Mean . . .	3·5	3·0	3·1	6·5	26·6	26·3	20·4	9·6

§ 28. Table X. shows how the number of thunderstorms varies throughout the year. The figures are percentages of the total number recorded. The epochs covered and the sources of the figures are as follows: Edinburgh, 1770-1896, Mossman (*Trans. R. S. E.* vol. xxxix. p. 63); London, 1763-1896, Mossman (*Quarterly Journal of R. Met. Socy.* vol. xxiv. 1898, p. 31); Paris (Parc St Maur), 1873-93, Renou (*Met. Zeit.* 1894, p. 277); Hungary, mean from numerous stations, 1871-95, Héjas (*Met. Zeit.* 1899, p. 219); Batavia, 1867-95 (*Mag. and Met. Observations*, vol. xviii. 1895); Russian provinces, 1870-79, and Italy (1882-83) from Arrhenius (*Met. Zeit.* 1888, p. 348). In the last-mentioned cases the data for winter are lumped together, so for convenience the year starts with April.

TABLE X.

Relative frequency of Thunderstorms throughout the Year.

	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Edinburgh .	3·3	12·6	20·8	26·5	18·8	7·2	2·2	0·9	0·9	1·8	1·2	1·2
London .	6·8	12·7	18·8	25·5	19·2	9·3	3·1	1·7	0·9	0·6	0·3	1·6
Paris . .	7·5	14·9	21·6	22·0	17·0	9·9	3·5	0·4	0·4	0·2	0·4	2·2
Hungary .	5·7	16·2	25·8	23·3	17·0	8·9	2·4	0·6	0·3	0·1	0·4	1·2
Batavia .	10·5	7·9	5·5	4·8	8·8	3·4	6·8	12·2	10·9	10·4	9·2	11·1
West Siberia	0·8	11·5	28·0	36·4	20·1	3·0	0·2					
North Russia	0·7	7·5	27·8	32·2	24·4	5·5	2·1					
South "	3·3	14·2	27·3	26·4	15·2	8·8	5·3					
Italy . .	7·4	7·2	19·1	17·2	16·5	14·0	18·2					

Alongside this last table it is instructive to place the following particulars as to the number of persons killed by lightning in different months in England and Wales during the twenty-four years 1857-80 (R. Lawson, *Quart. Journal R. Met. Soc.* vol. xv. 1889, p. 140), with corresponding data in the United States during the eight years 1891-98 (Henry, *Bull.* No. 26, U.S. Dept. of Agriculture, 1899). The six winter months October-March are grouped together.

TABLE XI.

Total deaths by Lightning.

	April.	May.	June.	July.	August.	September.	Winter.	Total.
England and Wales (24 years)	10	46	127	114	93	30	23	443
United States (8 years)	116	337	641	683	434	153	82	2496

§ 29. If we compare Tables VIII., IX., and X., with Tables I., II., and III., we see that to a certain extent high thunderstorm frequency and low potential gradient vary in parallel lines. Thus, thunderstorm frequency and intensity are greatest about midsummer, when potential gradient is least, and there is at most stations a minimum of potential gradient in the afternoon at about the same hour as the thunderstorm maximum. The connexion is, however, far from close. Thus we have the thunderstorm minimum occurring alongside of the early morning potential gradient minimum; and the diurnal and annual variations in thunderstorms appear much more accentuated than the corresponding variations in potential gradient.

§ 30. When we consider the influence of geographical position, we also find thunderstorm frequency more variable than potential gradient, at least so far as is at present known. If we accept Exner's observations of potential as representative, the mean potential gradient does indeed diminish as we pass from temperate to tropical climates, but we do not encounter such notable discrepancies as are presented in Table XII. The data are from the sources already mentioned.

TABLE XII.

Average Number of Thunderstorms in a Year.

Edinburgh, 1770-1896.	London, 1763-1896.	Paris, 1873-93.	Batavia, 1867-95.
6·4	10·7	27·3	120

It must be allowed that the drawing of safe conclusions from thunderstorm data is particularly difficult, owing to the differences between the records from stations in the same latitude. Instructive illustrations are afforded in Plate I. of the memoir by A. J. Henry, on United States thunderstorms mentioned above. In some parts of the Pacific states the average annual number is put at from 1 to 5, as against 30 to 45 in some of the central and south-eastern states. Even in some quite small areas, especially islands or coast districts containing high mountains, the differences in thunderstorm frequency are great. There is the further consideration that a great deal may depend on the observer.

§ 31. Other thunderstorm data are more independent of the imagination, but all seem attended by sources of uncertainty. An illustration is afforded by the following statistics from the paper by Lawson already mentioned, giving the average number of persons killed annually per ten million inhabitants in various districts of England and Wales. The original treats separately the epochs 1852-61, and three following decades. Table XIII. gives only the final means. The letter M denotes "midland"; N, north; S, south, &c.

TABLE XIII.

Persons killed annually per Ten Million Inhabitants.

London.	S.E.	S.M.	E.	S.W.	W.M.	N.M.	N.W.	York.	N.	Wales.
1·3	6·0	12·3	12·7	5·6	10·7	18·0	6·6	11·4	10·4	9·1

The north-midland district (Leicester, Rutland, Lincoln, Nottingham, and Derby) showed the largest proportion of persons killed during each decade, and London (metropolitan area) the least. From what is known otherwise, there can hardly be any doubt that one would be seriously in error if one supposed the figures in Table XIII. to be an exact measure of relative thunderstorm intensity. The figures are largely influenced by the fact that persons employed indoors have much less chance of being struck by lightning than those out of doors. As emphasizing this fact, Lawson mentions that between 1852 and 1880, only 104 females were killed by lightning, as against 442 males.

§ 32. Table XIV. gives the mean annual number of thunderstorms recorded per decade at Edinburgh, London, and Tilsit.

The Edinburgh and London data are from the papers by Mossman already mentioned, those for Tilsit are due to Kassner (see *Met. Zeit.* for 1894, p. 237).

TABLE XIV.

Mean Annual Number of Thunderstorms.

Decade ending	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890
Edinburgh .	4·0	4·9	5·7	7·7	8·7	5·7	8·5	5·4	10·6	9·4
London .	7·9	9·5	8·3	11·5	11·8	10·5	11·9	9·8	15·7	13·0
Tilsit .	...	...	...	12·1	12·1	18·1	15·3	11·9	17·6	21·8

Mossman expresses the opinion that the apparent recent increase in the frequency of thunderstorms at Edinburgh and London is, to some extent at least, a true phenomenon. Unquestionably the two sets of figures show corroborative features—notably the fall in the decade 1861 to 1870—but it is difficult to feel certain that the notable extension in the limits of both cities may not have exercised an influence. The diminished intensity in the decade 1861-70 is, it may be added, in accord with Lawson's vital statistics. In Germany various authorities believe in a great recent increase in thunderstorms. Von Bezold (*Berlin. Sitz.* 1899, No. 18) has given a table showing the number per million of insured houses struck in Bavaria for each year from 1833 to 1897. Prior to 1868, the number struck in one year never exceeded 78 per million; between 1868 and 1883 it exceeded 100 per million in five, but only five, years; since 1884 it has only once been less than 100 per million, and it exceeded 200 per million in 1895, 1896, and 1897. Kassner (reviewed *Met. Zeit.* 1890, p. 385), dealing with similar insurance statistics for Central Germany, concluded that during the twenty-six years 1864 to 1889, destructive lightning strokes had increased 126 per cent. as against an increase of only 11 per cent. in houses. Von Bezold seems to accept a large increase in thunderstorm intensity in Germany as an undoubted fact, and he is disposed to associate it with the great increase in smoky factory chimneys, and in the number of wires and rails all over the country. It is possible, of course, that changes in the ordinary height or construction of buildings, or influences which only an insurance expert could assess, may have had an effect.

§ 33. Table XV. gives data based on the number of trees of different species struck by lightning during a series of recent years in the forests of Lippe, in Germany, as quoted by Henry (*l.c.*).

TABLE XV.

Species of Tree.	Oak.	Fir.	Pine.	Beech.	Larch.	Ash.	Birch.
Total struck .	159	59	20	21	7	5	4
Mean liability .	57	39	5	1	...	...	...

In calculating the liability, allowance is made for the relative numbers of the different species. The different years are treated separately, the liability of beech to be struck being taken as unity throughout. Prohaska (see *Met. Zeit.* 1899, p. 128) gives somewhat analogous data for Styria. He concludes that oaks, poplars, and pear trees are especially liable to be struck, while beech is exceptionally safe. Jonesco (see Henry, *l.c.*) has concluded from experiments that fresh wood, rich in starch, but poor in fatty material, possesses the greatest electrical conductivity, and that the conductivity in some species of living trees varies a good deal with the season of the year. He believes that the liability to be struck by lightning is greater the higher the conductivity. Allowance must, however, be made for the fact that different species of trees attain different heights, and that one species may be common in marshy, another on rocky ground. According to Hellman (quoted by Henry), the liability to lightning stroke on different soils in Germany may be put at: chalk 1, clay 7, sand 9, loam 22. Differences of this kind might influence the apparent liability of different species of trees to be struck.

§ 34. Luminous discharges from pointed objects are not infrequent in mountainous districts, especially during thunderstorms. On the Sonnblick, where the phenomenon is of frequent occurrence, St Elmo's fire has been found to answer to a discharge sometimes of positive, sometimes of negative electricity (Elster and Geitel, *Met. Zeit.* 1891, p. 321, and 1894, p. [68]). The colour and appearance of the light differ in the two cases, red predominating in a positive, blue in a negative discharge. Stade (*Met. Zeit.* 1898, p. 238) also describes the appearance of St Elmo's fire of different signs, as observed on the Brocken.

Auroras.

§ 35. A description of the more prominent features of aurora will be found in the *Ency. Brit.* vol. xvi. pp. 177, 178, 183. Table XVI. contains some statistics more recently published as to the relative frequency of auroras in different months of the year. The data for Scotland and London are from papers by Mossman (see *Met. Zeit.* 1898, p. 307), the rest are quoted by Ekholm and Arrhenius (*Kongl. Svenska Vetenkaps-Akademiens Handlingar*, Bd. 31, No. 2, 1898). The figures are percentages of the mean number for the year.

TABLE XVI.

Relative frequency of Auroras throughout the Year.

	N.E. Scotland (122 years).	London (189 years).	Norway (1861-95).	United States (1871-93).	From 16° S. to 30° S. (1783-1894).
January .	10·9	8·8	11·5	8·3	4 6
February .	12·7	10·5	15·2	9·2	5·8
March .	12·0	10·2	15·4	8·8	9·4
April .	7·1	10·7	4·1	10·9	12 7
May .	2·2	4·0	0·3	8·0	3·8
June .	0·0	1·1	0·0	6·7	3·8
July .	0·4	1·9	0 0	7·7	2·4
August .	4·4	5·8	0·8	7·6	7 2
September	12·9	14·5	9·8	10·9	11·9
October .	15·8	18·9	18·2	10·8	21·1
November	12·0	9·8	15·0	7·8	10·4
December .	9·6	8·4	11·9	5·8	6·9

Table XVI. is in general agreement with the statement in the *Ency. Brit.* that auroras are most frequent near the equinoxes. In comparing winter and summer data, especially in high latitudes, it must be remembered that faint auroras are invisible in twilight.

§ 36. Table XVII. may be regarded as a continuation of one in the *Ency. Brit.* vol. xvi. p. 178. It gives Wolf's relative sun-spot numbers alongside of numbers proportional to the frequency of auroras. In the case of Edinburgh the figures are the actual number of auroras as given by Mossman (*l.c.*). The other data are from a paper by Ekholm and Arrhenius (*K. Svenska Vet.-Akad. Hand.* Bd. 31, No. 3, 1898).

TABLE XVII.

Sun-spot and Auroral Frequency.

Year.	Wolf's Number.	Auroral Frequency.		
		Edinburgh.	N. America.	16° to 30° S.
1869	73·9	5	...	3
1870	139·1	19	...	123
1871	111·2	21	408	60
1872	101·7	8	565	105
1873	66·3	12	781	8
1874	44·6	10	1443	11
1875	17·1	4	741	6
1876	11·3	0	878	2
1877	12·3	2	877	1
1878	3·4	1	258	0
1879	6·0	0	405	1
1880	32·3	12	648	5
1881	54·3	2	804	17
1882	59·6	5	860	138
1883	63·7	2	686	28
1884	63·5	3	533	0
1885	52·2	5	728	2
1886	25·4	6	974	8
1887	13·1	0	810	3
1888	6·8	1	759	9
1889	6·3	0	336	1
1890	7·1	0	358	1
1891	35·6	7	732	1
1892	73·8	9	814	48
1893	84·9	2	1087	9
1894	78·0	8	...	12

§ 37. During the polar year, September 1882 to September 1883, numerous aurora observations were made at many of the stations. Those at the Finnish station, Sodankylä, have been discussed by Lemstrom and Biese (*Exped. Polaire Finlandaise*, t. iii., Helsingfors, 1898). In addition to the more usual phenomena the Finnish observers noticed a variety of others. On a good many occasions, in the absence of ordinary aurora, they saw a yellowish-white illumination, showing in the spectroscope the characteristic auroral line (wave-length 5569×10^{-7} mm., according to Lemstrom). On some occasions, in the absence of any phenomenon visible to the unaided eye, Lemstrom saw the auroral line wherever he turned the spectroscope. The most outstanding phenomena, however, described by Lemstrom and Biese are artificially produced luminosities, in the shape usually of flames, but occasionally resembling auroral rays. The auroral line was usually detected, but was feeble. The apparatus consisted of a number of sharp points connected by wires carried on insulators, the whole enclosing an area of several hundred square metres on the top of one or other of a series of hills near Sodankylä. Sometimes a Holtz machine was introduced into the wire circuit, and when worked it enhanced the effect, or even rendered it visible when previously unseen. Coloured illustrations represent the artificial phenomenon on several occasions as very prominent, and extending to a considerable height.

§ 38. At the Danish polar station, Godthaab, Paulsen saw on several occasions auroral sheets, which seemed to be suspended vertically like curtains and to sweep past with great velocity, travelling from magnetic south. At Paulsen's suggestion, Lieut. Vedel of the Ryder Arctic Expedition, 1891, 1892, kept a lookout for this phenomenon, and was able on a variety of occasions to observe the declination magnet during its occurrence. According to these observations—made on an island in Scoresby Sound, 70° 27′ N. lat. —the needle moved to the west as the auroral curtain approached from the south, oscillated as the curtain passed overhead, and then moved to the east as the curtain receded towards the north (Paulsen, *Bull. de l'Acad. Roy. . . . de Danemark*, 1894, p. 148). Paulsen believes the phenomenon to imply the existence of an electric current directed downwards in the space occupied, or seemingly occupied, by the auroral curtain.

Height of auroras.

§ 39. Numerous attempts have been made to determine the height of auroral displays. Simultaneous theodolite observations have frequently been made from two stations at a considerable distance apart. The calculated heights in mean latitudes have often exceeded 100 kilometres. At Godthaab the calculations of the Danish observers often put auroral arcs at heights under 10 kilometres, and occasionally under 2. From the observations at Sodankylä, Lemström thought it doubtful whether the objects seen from the two ends of the base were really the same. The question has been treated with great fulness of detail by Cleveland Abbe (*Terrestrial Magnetism*, vol. iii., 1898, pp. 5, 53, and 149); he seems disposed to doubt whether what the observer sees as aurora has an independent objective existence.

§ 40. The subject of lunar influence has been treated by Ekholm and Arrhenius in several papers dealing with a great mass of observations, and containing many useful references (*K. Sven. Vet.-Akad. Hand.*, Bd. 19, No. 8; Bd. 20, No. 6; Bd. 31, No. 2). In the case alike of electric potential, thunderstorms, and auroras, they find a conspicuous tropical lunar period, 27·32 days. They conclude, however, that the synodic lunar period, 29·53 days, found by Fritz in auroras is not real, arising simply from the fact that moonlight affects the visibility of auroras. An investigation by Polis (*Met. Zeit.*, 1894, p. 230) seems to indicate a synodic lunar period in thunderstorms at Aachen. Investigations into thunderstorm data at Paris by Renou (*Comptes Rendus*, cxviii. p. 1401), and into similar data at Batavia (*Batavia Observations*, vol. xviii. 1895), on the other hand, would indicate that if a lunar influence exists it is small. Ekholm and Arrhenius (*K. Sven. Vet.-Akad. Hand.*, Bd. 31, No. 3) have also examined into the existence of a period of approximately twenty-six days. They decide in favour of the existence of such a period, not merely for thunderstorms and auroras, but also for magnetic storms and for the amplitude of diurnal variation of magnetic elements. The most probable value for the period is, they find, 25·929 days. The methods and conclusions of Ekholm and Arrhenius have been critically discussed by Schuster in several papers with somewhat unfavourable results. (See MAGNETISM, TERRESTRIAL, § 14).

AUTHORITIES.—LORD KELVIN (Sir W. Thomson). *Papers on Electrostatics and Magnetism.*—GEORGES LE CADET. *Étude du champ électrique de l'Atmosphère.* Paris, Lyon, 1898. —McADIE and HENRY. "Lightning and the Electricity of the Air," *Bulletin* No. 26, U.S. Department of Agriculture, Weather Bureau. Washington, 1899.—Publications of Observatories running Water-droppers, *e.g.*, Greenwich, *Magnetical and Meteorological Observations*; Batavia, *Observations made at the Magnetical and Meteorological Observatory at Batavia* (especially vol. xviii., for 1895); Lisbon, *Annaes do Observatorio do Infante D. Luiz.*—Publications descriptive of Observations of Aurora at Stations of International Polar Year 1882-83 (Fort Rae, Godthaab, &c.), more especially the two following, descriptive also of observations of potential gradient: *Observations faites au Cap Thorsden Spitzberg*, tome ii. Stockholm, 1887. *Expédition Polaire Finlandaise* (1882-84), tome iii. Helsingfors, 1898. The following, amongst somewhat numerous, historical reviews of our knowledge of atmospheric electricity, must also be noted:—EXNER. *Wien. Sitzungsberichte*, xcii. (Abth. ii.), 1886, p. 222.—ARRHENIUS. *Met. Zeitschrift*, 1888, p. 297 and p. 348.—ELSTER and GEITEL. *Met. Zeitschrift*, 1890, p. 252, and *Bull.* No. 11, U.S. Weather Bureau, part ii. p. 510. Washington, 1895.—SCHUSTER. *Nature*, vol. liii., 1896, p. 207.—TRABERT. *Met. Zeitschrift*, 1898, p. 401. —EXNER. *Met. Zeitschrift*, 1900, p. 529. (C. CH.)

Atrek, a river rising in the Persian province of Horassan, enters the S.E. corner of the Caspian Sea, after a course of nearly 300 miles. In its lower course it forms the frontier between Persia and Russia.

Attleborough, a town of Bristol county in south-eastern Massachusetts, U.S.A. It has an area of 28 square miles, with a rolling surface, and contains a large rural population, with a village of considerable size, bearing the same name as the town. This has manufactures of a varied character, largely jewellery. It is on the New York, New Haven, and Hartford railway. It was incorporated in 1694. Population (1890), 7577; (1900), 11,335.

Attock, a town and fortress of British India, on the Indus, in the Rawal Pindi district of the Punjab, 47 miles by rail from Peshawar. In 1883 an iron girder bridge of five spans was opened, which carries the North-western railway to Peshawar, and which also has a subway for wheeled traffic and foot passengers. The military importance of Attock has diminished, but it still has a garrison of artillery and infantry. St. Peter's Church is a fine building. Population, about 3000.

Atui. See COOK ISLANDS.

Aube, a department in the E. of France, watered by the Seine and its tributary the Aube.

Area, 2327 square miles, with 26 cantons and 446 communes. The population decreased from 257,374 in 1886 to 251,435 in 1896 and 246,596 in 1901. The chief towns are Troyes (52,000 inhabitants in 1896), Bar-sur-Aube, Bar-sur-Seine, Nogent, Arcis, and Romilly. Births (1899), 4547, of which 463 were illegitimate; deaths, 5641; marriages, 1693. In 1896 there were 696 schools, with 32,000 pupils. One per cent. of the population was illiterate. The land under cultivation comprised 1,383,200 acres, of which 918,840 acres were plough-land, and 41,990 acres in vines. The wheat crop in 1899 yielded a value of £1,100,251. Rye, barley, oats, and mangold-wurzel also contribute to the agricultural wealth of the department. The production of vines in 1899 amounted to the value of £400,000. In 1899 the live stock numbered 31,220 horses and 88,790 cattle. As it lacks both coal and iron, the department does little in the way of working metals, producing only cast-iron and steel to the value in 1898 of £60,000; but the textile industry has assumed large proportions around Troyes, where the cotton manufacture employs 24,000 looms and 70,000 spindles.

Aubervilliers-les-Vertus, a French village in the arrondissement of St Denis, department of Seine, on the canal St Denis, 2 miles from right bank of Seine and 1 mile N. of the fortifications of Paris. Near it is a fort of the 2nd line. Manufactures include chemicals, glue, cardboard, printing ink, and glass, and there are iron-works. Population (1881), 19,310; (1891), 24,757; (1896), 27,061; (1901), 31,215.

Auburn, capital of Androscoggin county, Maine, U.S.A., situated on the Androscoggin river, which furnishes abundant water-power. It has communication by three railways, the Maine Central, the Grand Trunk, and the Portland and Rumford Falls. Its manufactures consist mainly of cotton goods and boots and shoes. Population (1880), 9555; (1890), 11,250; (1900), 12,951.

Auburn, capital of Cayuga county, New York, U.S.A., situated in 42° 55′ N. lat. and 76° 35′ W. long., at the outlet of Owasco lake, at an altitude of 673 feet. Though the site is hilly its plan is regular. The city is divided into ten wards, has a good water-supply pumped from the lake, and most of its streets are macadamized.

Its manufactures are extensive, in 1890 having a value of more than $9,000,000, and consist largely of agricultural implements and boots and shoes. The city is traversed by the New York Central and Hudson River and the Lehigh Valley railways. It was the home of William H. Seward, secretary of state during the Civil War and the period of reconstruction. Population (1880), 21,924; (1890), 25,858; (1900), 30,345.

Auch, chief town of department Gers, France, 426 miles S.S.W. of Paris, on railway from Agen to Toulouse. There are a civil and military hospital and a large asylum. Important articles of commerce are wine, corn, and wool; poultry are extensively exported, and its pâtés-de-foie (of duck) are esteemed; marble and spar are worked. Population (1881), 9560; (1891), 9273; (1896), 9313; (1901), 13,939.

Auckland, an important seaport, on the southern shore of Waitemata harbour, Eden county, in the province of Auckland, North Island, New Zealand. It is the largest and most beautiful town in New Zealand. Its public library and art gallery owe much to the generosity of Sir George Grey and other citizens. Its museum shows the best existing collection of Maori art. The extension of the city has not marred the charm of the surroundings. These, indeed, have been beautified by gardens and tree planting. The industries are substantial, among them being sugar-refining, shipbuilding, and manufactures of rope and twine, bricks and tiles, while there are also timber works. The harbour accommodation is very good, and includes two graving docks, of which one (the Calliope) is 525 feet long, the other 312. The total trade in 1893 was £2,744,277; in 1896, £3,236,605; in 1899, £1,071,323. The registered tonnage of shipping in 1899 was—inwards, 311,827 tons; outwards, 214,351 tons. Population of borough (1871) 18,000, (1881) 26,083, (1901) 34,216; of province (1901) 175,854.

Aude, a department in the S. of France, bordering on the Mediterranean. It is traversed by offshoots of the Pyrenees and of the Corbières, and watered by the Aude.

Area, 2448 square miles, distributed among 31 cantons and 439 communes. Population, 332,080 in 1886; 310,513 in 1896; 313,531 in 1901. The chief towns are Carcassonne, the capital, with a population of 30,000 in 1896, Castelnaudary, Limoux, and Narbonne (30,000 inhabitants). Births in 1899, 6233, of which 232 were illegitimate; deaths, 6227; marriages, 2286. In 1896 the primary schools numbered 836, with 45,000 pupils. Four per cent. of the population was illiterate. The surface under cultivation measured 975,650 acres, of which 476,710 acres were plough-land, and 284,000 acres laid out in vines. In this latter culture Aude holds the third rank in France, in respect of extent of cultivation. In 1899 the wheat crop yielded a value of £463,203; maize is one of the cultures next in importance. In 1899 the vines gave a gross return of the value of £4,040,000. The mulberry is also grown. In 1898 the live stock numbered 25,136 horses and 31,080 cattle. Aude produces a little iron and (1898) 8000 tons of sea salt. There is no working in metals, and the other industries, giving way before all-engrossing viticulture, are quite inconsiderable.

Audenarde. See OUDENARDE.

Audran, Edmond (1812-1901), French musical composer, was born at Lyons in 1842. He studied music at the École Niedermeyer, where he won the prize for composition in 1859. Two years later he accepted the post of organist of the church of St Joseph at Marseilles. He made his first appearance as a dramatic composer at Marseilles with *L'Ours et le Pacha* (1862), a musical version of one of Scribe's vaudevilles. This was followed by *La Chercheuse d'Esprit* (1864), a comic opera, also produced at Marseilles. Audran wrote a funeral march on the death of Meyerbeer, which was performed with some success, and made various attempts to win fame as a writer of sacred music. He produced a mass (Marseilles, 1873), an oratorio, *La Sulamite* (Marseilles, 1876), and numerous minor works, but he is known almost entirely as a composer of the lighter forms of opera. His first Parisian success was made with *Les Noces d'Olivette* (1879), a work which speedily found its way to London and (as *Olivette*) ran for more than a year at the Strand Theatre (1880-81). Audran's music has, in fact, met with as much favour in England as in France, and all save a few of his works have been given in a more or less adapted form in London theatres. Besides those already mentioned, the following have been the most undeniably successful of Audran's many comic operas: *Le Grand Mogol* (Marseilles, 1876; Paris, 1884; London, as *The Grand Mogul*, 1884), *La Mascotte* (Paris, 1880; London, as *The Mascotte*, 1881), *Gillette de Narbonne* (Paris, 1882; London, as *Gillette*, 1883), *La Cigale et la Fourmi* (Paris, 1886; London, as *La Cigale*, 1890), *Miss Hélyett* (Paris, 1890; London, as *Miss Decima*, 1891), *La Poupée* (Paris, 1896; London, 1897). Audran was one of the best of the successors of Offenbach. He had little of Offenbach's humour, but his music is distinguished by an elegance and a refinement of manner which lift it above the level of opéra bouffe to the confines of genuine opéra comique. He was a fertile if not a very original melodist, and his orchestration is full of variety, without being obtrusive or vulgar. Many of his operas, *La Mascotte* in particular, reveal a degree of musicianship which is rarely associated with the ephemeral productions of the lighter stage. He died 17th August 1901. (R. A. S.)

Auerbach, Berthold (1812-1882), German novelist, was born on 28th February 1812, at Nordstetten in the Black Forest. His parents were Jews, and he was intended for the priesthood; but, becoming estranged from Jewish orthodoxy by the study of Spinoza, he devoted himself to literature, and made a fortunate beginning in a romance on the life of Spinoza (1837), so interesting in itself, and so close in its adherence to fact, that it may be read with equal advantage as a novel or as a biography. A translation of Spinoza's works followed in 1841, and Auerbach turned to the class of fiction which has made him famous: the *Dorfgeschichten*, or stories of peasant life in the Black Forest, in which, as well as in *Barfüssele*, *Edelweiss*, and other novels of greater compass, he depicts the life of the south German peasant as Jeremias Gotthelf had painted the peasantry of Switzerland, but in a much less realistic spirit. When this vein was exhausted Auerbach returned to his first phase as a philosophical novelist, producing *Auf der Höhe*, *Das Landhaus am Rhein*, and other romances of profound speculative tendencies, turning on plots invented by himself. These were no exception to the general wearisomeness of long German novels, and Auerbach's fame will continue to rest upon his *Dorfgeschichten*, impaired as the celebrity of even these has been by the growing demand for a more uncompromising realism. Auerbach died at Cannes, 8th February 1882. (R. G.)

Auersperg, Anton Alexander, COUNT (1806-1876), after Grillparzer the most celebrated modern Austrian poet, was born at Laibach, 11th April 1806. Born to an ample fortune, he took a prominent part in public life, which became more active as the grip of absolutism gradually relaxed. At first the object of persecution and suspicion for his Liberal tendencies, he was in 1860 summoned by the Crown to represent Carinthia in the Diet, and was made a peer for life in the following year. His subsequent course was that of a determined opponent of federalism, but the current of events was too strong for him. He died at Gratz, on 12th September 1876. As a poet Auersperg gained great reputation by the anonymous *Walks of a Vienna Poet* (1831), a collection of lyrics displaying the humour, tender feeling, and power of natural description which continued to characterize him, and which excited especial attention by so pronounced a hostility to Metternich's despotic system that the author was obliged to print them at Hamburg. Subsequent volumes under the pseudonym of "Anastasius Grün" were no less successful, and in 1850 Auersperg further endeared himself to his countrymen by an epic of popular life, *Der Pfaff von Kahlenberg*. If not the greatest of Austrian poets, he is the most typically national. Among his works is a version of the English ballads of the Robin Hood cycle. (R. G.)

Augier, Guillaume Victor Émile (1820-1889), French dramatist, who with Dumas *fils* and Sardou, may be said to have held the French stage during the second empire, was born at Valence in Drôme on the 17th September 1820. He received a good education and studied for the bar. In 1844 he wrote a play in two acts and in verse, *La Ciguë*, refused at the Théâtre Français, but produced with considerable success at the Odéon. This settled his career. Thenceforward, at fairly regular intervals, either alone or in collaboration with some well-known writer—Musset, Sandeau, Labiche—he produced plays which were in their way eventful, and in the case of the *Fils de Giboyer*—which was regarded as an attack on the clerical party in France, and only brought out by the direct intervention of the emperor—caused some political excitement. His last comedy, *Les Fourchambault*, belongs to the year 1878. After that date he wrote no more, restrained by an honourable fear of producing inferior work. The Academy had long before, on the 28th January 1858, elected him to be one of its members. He died in his house at Croissy on the 25th October 1889. Such, in briefest outline, is the story of a life which Augier himself describes as "without incident"—a life in all senses honourable. The man respected himself and his art, and his art on its ethical side—for he did not disdain to be a teacher—has high qualities of rectitude and self-restraint. Uprightness of mind and of heart, generous honesty, as M. Jules Lemaître well said, constituted the very soul of all his dramatic work. Nor are exemplifications far to seek. In the *Mariage d'Olympe* (1855) the courtesan is shown as she is, not glorified as in Dumas's *Dame aux Camélias*. In *Gabrielle* (1849) the husband, not the lover, is the sympathetic, poetic character. In the *Lionnes pauvres* (1858) the wife who sells her favours comes under the lash. Greed of gold, social demoralization, lust of power, these are satirized in *Les Effrontés* (1861), *Le Fils de Giboyer* (1862), *Contagion* (1866), *Lions et Renards* (1869)—which, with the *Gendre de M. Poirier*, reach the high-water mark of Augier's art; while in *Jean de Thommeray* (1873), brought out after the great reverses of 1870, the regenerating note of patriotism rings high and clear. But it would be unfair to suggest that Augier was a preacher only. He was a moralist in the great sense, the sense in which the term can be applied to Moliere and the great dramatists—a moralist because of his large and sane outlook on life. Nor does the interest of his dramas depend on elaborate plot. It springs from character and its evolution. His men and women move as personality, that mysterious factor, dictates. They are real, several of them typical. Augier's first drama, *La Ciguë*, belongs to a time (1844) when the romantic drama was on the wane; and his almost exclusively domestic range of subject scarcely lends itself to lyric outbursts of pure poetry. But his verse, if not that of a great poet, has excellent dramatic qualities, while the prose of his prose dramas is admirable for directness, alertness, sinew, and a large and effective wit. Perhaps it wanted these qualities to enlist laughter on his side in such a war as he waged against false passion and false sentiment. (F. T. M.)

Augsburg, a town and episcopal see of Bavaria, Germany, chief town of the district of Swabia, on the river Lech, 39 miles W.N.W. from Munich by rail. The newer buildings, all in the recently built W. quarter of the city, include law courts, theatre, and municipal library, with 150,000 vols. Augsburg is particularly well provided with special and technical schools. It has become a centre of the acetylene gas industry of Germany, and the number of artisans engaged in its various works now exceeds 19,000. Population (1885), 65,905; (1900), 89,109.

Augusta, a fortified seaport of the province of Syracuse, Sicily, Italy, on an island on the S. side of Cape Santa Croce, on the E. coast of the island, 19 miles by rail N. from Syracuse. It is connected with the mainland by a bridge, and has a spacious harbour, fortified, with a small foreign and some coasting trade. The people cure fish, crush out olive oil, quarry chalk, burn lime, and extract salt. Population, about 14,000. The town was founded in 1232 by the emperor Frederick II., and is memorable for the defeat (1676) of the Dutch admiral De Ruyter by the French under Duquesne, in which De Ruyter was mortally wounded.

Augusta, capital of Richmond county, Georgia, U.S.A., in 33° 29' N. lat. and 81° 51' W. long., on the west bank of the Savannah, at the head of navigation and at the falls in the river. These afford a magnificent water-power, which is extensively utilized in manufactures. The city stands at 143 feet above sea-level, is divided into five wards, is well drained and lighted, and is supplied with water from the Savannah. It is the most important cotton manufacturing centre of the south. In 1890 the cotton factories employed 4500 hands, and their annual product was valued at over $6,000,000. The assessed valuation of real and personal property in 1899 was $18,780,076, the net debt $1,896,469, and the tax rate $24.76 per $1000. Population (1880), 21,891; (1890), 33,300; (1900), 39,441, of whom 995 were foreign-born and 18,487 were negroes.

Augusta, capital of Kennebec county and of the state of Maine, U.S.A., on the Kennebec, at the head of tide and navigation. Its site is hilly, the land rising sharply from the river on both sides. The city is regularly laid out, and is entered by the Maine Central railway. Few of the streets are paved, and the drainage system is incomplete. There is a fine public library, and the state-house, a beautiful structure, stands on an eminence in the southern outskirts. It has considerable manufactures, chiefly in cotton, wool, and lumber, the falls in the river at this point furnishing water-power. It was settled under the name of Cushnoc in 1754, was afterwards a part of Hallowell, was incorporated as the town of Augusta in 1797, was made the capital in 1827, and received a city charter in 1849. Population (1880), 8665; (1890), 10,527; (1900), 11,683.

Augusta, Marie Louise Catherine, (1811-1890), Queen of Prussia and German Empress (1811-1890), was born at Weimar on the 30th of September 1811, the second daughter of Charles Frederick, grand-duke of Saxo-Weimar-Eisenach, son of Karl August, the patron of Goethe and Schiller. In 1829 she married Prince William, second son of Frederick William III. of Prussia; her older sister, Princess Marie, had two years before married Charles, the third son of the king of Prussia, and was the mother of Prince Frederick Charles, the famous general. There were two children of the marriage, Frederick (*q.v.*), the future emperor, and Louise (*b.* 1838), who married the grand-duke of Baden. In 1840, on the death of his father, Prince William, who, as his elder brother was childless, was now heir-presumptive, took the title of Prince of Prussia; in 1858 he became Prince Regent, and in 1861 succeeded to the throne. In 1871 he assumed the title of German emperor. The princess brought with her from Weimar a keen interest in art and literature; she continued to correspond with Goethe till his death. She also gave considerable attention to political affairs and was (again a tradition of the court of Weimar) more favourable to constitutional government and political liberty than was quite consistent with the usual tone of the Prussian court. After 1840 she and her husband generally lived at Coblenz, which always remained her favourite place of residence; but when in Berlin, especially after 1848, she became to some extent the centre of a Liberal opposition to the Government. This attitude she continued after Prince William had become king, and her influence was generally unfavourable to the policy and person of Bismarck, who in his posthumous memoirs has left a record of the difficulties which he sometimes experienced from her opposition. She was greatly interested in works of charity and benevolence and took an active part in the organization of the Red Cross Society and the Good Samaritans, established for the relief of sufferers in time of war. The old Weimar traditions continued to influence her to her latest years, and she had little sympathy with the military spirit which prevailed at the Prussian court or with the exaggeration of national feeling which became common after the great war. After 1870 again her dislike of Bismarck's policy was increased by his struggle with the Church, for though a Lutheran she always showed much interest in the Roman Catholic Church as in the worship of other religious denominations, especially that of the Anglican Church, in the ministrations of which she found much comfort in her declining years. She died in Berlin on the 7th of January 1890. (J. W. HE.)

Augustowo, a district town of Russian Poland, 135 miles S. of Suwalki, on the canal of the same name (65 miles), connecting the Vistula with the Niemen by means of the Netta, Czernoganza, and several lakes. It has a considerable export trade to the Baltic Sea. Population (1897), 12,746.

Aulie-ata, a small district town and fort of Russian Turkestan, province of Syr-daria, 260 miles N.E. of Tashkent on the highway to Vyernyi, situated on the Talas river at the western end of the high Alexandrovskiy range, its altitude being 5700 feet. The inhabitants of the town are mostly Sarts and Tajiks trading in cattle, horses, hides, &c. The population in 1897 was 12,006.

Aumale, Duc d'. See ORLEANS.

Aundh, a native state of India, in the Deccan division of Bombay, ranking as one of the Satara Jagirs. Its area is 447 square miles; its population (65,146 in 1891) was 63,933 in 1901; its gross revenue in 1897-98 was Rs.1,89,311, of which Rs.31,779 was expended on public works; the number of police was 65; the boys at school numbered 998. The chief, whose title is Pant Pratinidhi, is a Brahman by caste. The state has suffered severely from plague, the number of deaths down to July 1898 having been 661. The town of Aundh is situated in 17° 32′ N. lat. and 74° 22′ E. long., 26 miles south-east of Satara. Population, about 3500.

Aurangábád, a town and district of India, in the north-west division of the dominions of the Nizam of Haidarábád, on the river Kaum. It is a railway station on the Haidarábád-Godaveri line, 435 miles from Bombay. In 1891 the population, with military cantonments, was 33,887; in 1901 it was 26,165, showing a decrease of 23 per cent. It has a cotton mill, with 184 looms and 16,500 spindles, and employing 722 hands. The district of Aurangábád has an area of 6176 square miles. The population (1891) was 1,094,601, being 152 persons per square mile; in 1901 it was 984,700, showing a decrease of 13 per cent., due to the famine of 1899-1900. It contains the famous caves of Ajanta, and also the battle-field of Assaye.

Auray, (Breton *Alrac*), a town of France, department of Morbihan, in the arrondissement of Lorient, 12 miles W. of Vannes by rail. Iron manufacture and oyster culture are the chief industries; mine props are sent to England. Population (1881), 5064; (1891), 5071; (1896), 5193, (comm.) 6099; (1901), 6485.

Aurelle de Paladines, Louis Jean Baptiste d' (1804-1877), French general, was born at Malzieu, Lozère, on the 9th of January 1804, was educated at St Cyr, and entered the army as sub-lieutenant of foot in 1824. He served with distinction in Algeria against the Arabs between 1841 and 1848 (lieut.-colonel, officer Legion of Honour); took part in the Roman campaigns of 1848 and 1849 (colonel); and served as general of brigade throughout the Crimean War of 1854-56 (general of division, commander Legion of Honour). During the campaign in Lombardy in 1859 he commanded the ninth division at Marseilles, and superintended the despatch of men and stores to the seat of war (grand officer Legion of Honour). Placed on the reserve list in 1869, he was recalled to the Marseilles command on the outbreak of the Franco-German war of 1870-71. The revolution of the 4th September obliged him to leave Marseilles, but after the defeat of De la Motterouge and capture of Orleans by the Germans, he was appointed by the Government of National Defence, in November 1870, to the command of the army of the Loire. He was at first very successful against Von der Tann, winning the battle of Coulmiers and compelling the Germans to evacuate Orleans, but the capitulation of Metz had set free additional German troops to oppose him, and, after his defeat at Beaune la Rolande and subsequent unsuccessful fighting near Orleans, resulting in its recapture by the Germans in December, Aurelle retreated into the Sologne and was superseded. After the armistice he was elected to the National Assembly by the departments both of Allier and Gironde. He sat for Allier and was one of the fifteen officers chosen to assist in the peace negotiations. He was decorated with the grand cross of the Legion of Honour, and was given the command at Bordeaux, but retired in 1872. Elected a life senator in 1875, he supported the monarchical majority of 1876. He died at Versailles on the 17th of December 1877. He was the author of *La Première Armée de la Loire*, published in 1872. His fine qualities as a soldier were marred by indecision. (R. H. V.)

Aurillac, chief town of department Cantal, France, 366 miles S. of Paris by rail. There is a bronze statue (1883) of General Delzons. Its manufactures comprise copper wares, chemical products, umbrellas, goloshes, and sabots. Population (1881), 11,655; (1891), 12,587; (1896), 13,531, comm. 14,578; (1901), 17,459.

Aurora, a city of Kane county, Illinois, U.S.A., situated in 41° 46′ N. lat. and 88° 17′ W. long., on the Fox river, 39 miles W.S.W. of Chicago, at an altitude of

648 feet. Its plan is somewhat irregular, and it is divided into seven wards. Excellent railroad connexions are afforded by the Chicago, Burlington, and Quincy, the Chicago and North-Western and the Elgin, Joliet, and Eastern railways. Agricultural tools and machines are the chief manufactures. The shops of the Chicago, Burlington, and Quincy railway, employing upwards of 2000 hands, are situated here. The silver-plate works are also one of the largest industries in the city. It was settled in 1834. Population (1880), 11,873; (1890), 19,688; (1900), 24,147.

Aurora, a city of Lawrence county, Missouri, U.S.A., on the St Louis and San Francisco railway, at its junction with a branch of the Kansas City, Fort Scott, and Memphis railway, in the neighbourhood of a lead and zinc mining region. Population (1890), 3189; (1900), 6191.

Aurora polaris. See Atmospheric Electricity.

Aussig (Czech *Ousti nad Labem*), the chief town of a government district in Bohemia, Austria; a considerable river port on the Elbe. Population in 1890, 23,723; in 1900, 40,000; almost exclusively German and Catholic (2 per cent. Czech, 5 per cent. Protestant, and 2 per cent. Jewish). The adjoining communes of Kletsche and Schonpriesen were incorporated in 1899. In 1857 there were only 6404 inhabitants. All branches of industry and trade show great progress. The port, which was extended in 1891, was entered in 1896 by 1700 passenger and 1776 freight steamers, together with 7800 sailing vessels and towed barges. The principal articles forwarded are lignite, coal, sugar, stone and stoneware, corn, fruit, flour, cotton, rice, oil, fat, salt, and petroleum. In addition to the important textile, chemical, and boat-building industries, &c., its manufactures now comprise paraffin, oils, tar, colouring stuffs, machinery, glass, pianos, leather, malt, &c. Aussig was the birthplace of the painter Raphael Mengs (1728-79).

Austin, capital of Mower county, Minnesota, U.S.A., on the Red Cedar river, at an altitude of 1200 feet. The plan is quite regular, and the city is on the Chicago and Great Western, and the Chicago, Milwaukee, and St Paul railways. Population (1880), 2305; (1890), 3901; (1900), 5474.

Austin, capital of Travis county, and of the state of Texas, U.S.A., in 30° 16′ N. lat. and 97° 43′ W. long., on the north bank of the Colorado. The river is not navigable. The city is divided into eleven wards; the site is level and the plan regular. The surrounding country is a rich agricultural region, producing cotton as its principal crop. The finest building is the capitol, which the state obtained by bartering 3,000,000 acres of land in the "Pan Handle." It is said to have cost $4,500,000. The city contains a number of state institutions; among them the Lunatic Asylum, the Deaf and Dumb Asylum, the Blind Asylum, and the University of Texas. The last had 65 instructors and 800 students in 1899. Austin has three railways—the Houston and Texas Central, the International and Great Northern, and the Austin and North-Western. It received its name from Stephen Austin, a prominent man in the early history of Texas. Its site was selected, and the city built to serve as the capital, work on it having been commenced in 1839, immediately after the separation of Texas from Mexico. Population (1880), 11,013; (1890), 14,575; (1900), 22,258.

Austin, Alfred (1835- ——), English Poet-laureate, was born at Headingley, near Leeds, 30th May 1835. His father, Joseph Austin, was a merchant of the city of Leeds; his mother, a sister of Joseph Locke, M.P. for Honiton. Mr Austin was educated at Stonyhurst, Oscott, and London University, where he graduated in 1853. He was called to the bar four years later, and practised as a barrister for a short time; but in 1861, after two comparatively false starts in poetry and fiction, he made his first noteworthy appearance as a writer with a satire called *The Season*, which contained incisive lines, and was marked by some promise both in wit and observation. In 1870 he published a volume of criticism, *The Poetry of the Period*, which was again conceived in a spirit of satirical invective, and attacked Tennyson, Browning, Matthew Arnold, and Mr Swinburne in no half-hearted fashion. The book aroused some discussion at the time, but its judgments were extremely uncritical. In 1881 Mr Austin returned to verse with a tragedy, *Savonarola*, to which he added *Soliloquies* in 1882, *Prince Lucifer* in 1887, *England's Darling* in 1896, and *The Conversion of Winckelmann* in 1897. For several years he edited *The National Review*, and has written many leading articles in the columns of *The Standard*. On Tennyson's death in 1892 it was felt that none of the then living poets, except Mr Swinburne or Mr William Morris, who were disqualified on other grounds, was of sufficient distinction to succeed to the laurel crown, and for several years no new Poet-laureate was nominated. In the interval the claims of one writer and another were much canvassed, but eventually, in 1896, Mr Austin was appointed. Since then he has written several occasional poems, suggested by contemporary events (in particular, the Jameson Raid), which have not escaped criticism. The chief characteristic of Mr Austin's poetry, as of the best of his prose, is a genuine and intimate love of nature. His prose idylls, *The Garden that I love* and *In Veronica's Garden*, are full of a pleasant, open-air flavour, which is also the outstanding feature of his *English Lyrics*. His lyrical poems are wanting in spontaneity and individuality, but many of them possess a simple, orderly charm, as of an English country lane. He has, indeed, a true love of England, sometimes not without a suspicion of insularity, but always fresh and ingenuous. In dramatic poetry he is less successful. His laureate poems have been considerably below the level of his earlier achievements; but it was a very unenviable task to assume the laurel in succession to two poets whose work is among the richest in English literature.

Australasia, a term used by English geographers in a sense nearly synonymous with the *Oceania* of Continental writers. It thus comprises all the insular groups which extend almost continuously from the south-eastern extremity of Asia to more than half-way across the Pacific. Its chief divisions are *Malaysia* with the *Philippines*; *Australia* with *Tasmania* and *New Zealand*; *Melanesia*, that is, New Guinea, New Britain, New Ireland, and York, the Solomons, New Hebrides, Santa Cruz, Fiji, Loyalties, and New Caledonia; *Micronesia*, that is, the Ladrones, Pelew, and Carolines, with the Marshall and Gilbert groups; lastly, *Polynesia*, that is, Samoa, Tonga, Cook, Tahiti, the Marquesas, Ellice, Hawaii, and all intervening clusters. The term is so far justified in that it harmonizes better than Oceania did with the names of the other continents, and also embodies the two essential facts that it is a south-eastern extension of Asia, and that its central and most important division is the great island-continent of Australia. In a more restricted sense the term Australasia corresponds to the large division including Australia, Tasmania, and New Zealand.

See *Australasia*, 2 vols. Stanford Compendium Series, new issue London, 1893-94.

AUSTRALIA.

Physical Geography.

AUSTRALIA is the only continent entirely in the southern hemisphere. A mostly unbroken coast-line faces the sea in majestic and stately curves, giving the whole land a character of compactness, which likens it in some way to portions of the African continent. Quite one-half of its area is drained towards the interior. There are, however, no rivers like the Congo or Nile, and no snow-capped mountains to act as feeders. The average height of the land is not more than 300 feet, the highest point, Mount Kosciusko, being only 7328 feet above sea-level, and well below the limits of perpetual snow. Australia lies between 10° 39′ and 39° 11½′ south lat., and between meridians of 113° 5′ and 153° 16′ east long. Its greatest length is 2400 miles from east to west, and the greatest breadth 1971 miles from north to south. The area is, approximately, 2,946,691 square miles, with a coast line measuring about 8850. This is equal to one mile to each 333 square miles of land, the smallest proportion of coast shown by any of the continents. The salient features of the Australian continent are its compact outline, the absence of navigable rivers communicating with the interior, the absence of active volcanoes or snow-capped mountains, its isolation from other lands, and its antiquity. Some of the most profound changes that have taken place on this globe in lifting mountains such as the Alps and the Himalayas, have taken place in Mesozoic times. Rocks high up on the shoulders of these great ranges were formed beneath the sea at a time when a great portion of the Australian continent was already dry land. Vast tracts of Europe and Asia have been submerged in Tertiary times. Australia has been for the most part above the sea since the period anterior to the great earth movements named. In this sense Australia has been rightly referred to as one of the oldest existing land surfaces. It has been described as at once the largest island and the smallest continent on the globe. While in one sense a large island, it conforms in general to the continental model. The general contours exemplify the law of geographers, as to having a high border around a depressed interior, and as to having the highest mountains on the side of the greatest ocean. The main dividing range of Eastern Australia looks out upon the greatest and deepest water mass on the globe, the Tasman Sea and the South Pacific.

General character.

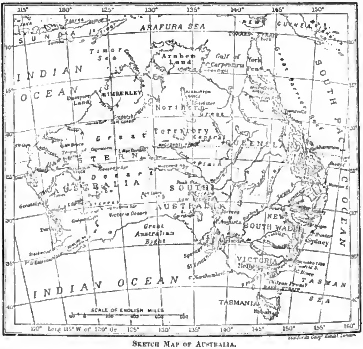
Australia stands up from the ocean depths in three fairly well marked shelves. The basal plain of these terraces is the bed of the Pacific, having an average depth of 15,000 feet. From this profound foundation rise Australia, New Guinea, and Melanesia, in varying slopes. The first ledge rising from the ocean floor has a depth averaging 8000 feet below sea-level. The outer edge of this basal ledge is roughly parallel to the coast of West Australia, and more than 150 miles from the land. Round the Australian Bight it continues parallel to the coast, until south of Spencer Gulf (the basal ledge still averaging 8000 feet in depth) it sweeps southwards to lat. 55°, and forms a submarine promontory 1000 miles long. The edge of the abyssal area comes close to the eastern coasts of Tasmania and New South Wales, approaching to within 60 miles of Cape Howe. The terrace closest to the land, known as the continental shelf, has an average depth of 600 feet, and connects Australia, New Guinea, and Tasmania in one unbroken sweep. Compared with other continents, the Australian continental shelf is extremely narrow. There are points on the eastern coast where the land plunges down to oceanic depths with an abruptness rarely paralleled. Off the Queensland coast the shelf broadens, its outer edge being lined by the seaward face of the Great Barrier Reef. From Torres Strait to Dampier Land the shelf spreads out, and connects Australia with New Guinea and the Malay Archipelago. An elongation of the shelf to the south joins Tasmania with the mainland. The vertical relief of the land above the ocean is one of the chief factors in determining the climate as well as the distribution of the fauna and flora of a continent. The land mass of Australia rises to a lesser mean height than that of any other continent. The chief mountain systems are parallel to, and not far from, the coast-line. Thus, taking the continent as a whole, it may be described as a plateau, fringed by a low-lying well-watered coast, with a depressed, and for the most part arid, interior. A great central plain covers quite 500,000 square miles of the continent. Although termed the Central Plain, it is situated a little to the east of a meridional line bisecting the continent. The vast bulk of this plain is situated to the south of the 22nd degree, but portions of it reach very close to the low-lying flats south of the Gulf of Carpentaria. The contour of the continent in the latitude of the Richmond River is as follows:—A short strip of coastal plain; then a sharp incline rising to a mountain range 4000 feet above sea-level, at a distance of 40 miles from the coast. From this a gently-sloping plateau keeps deepening until nearly down again to the sea-level, in a line due north of Spencer Gulf. Then there is a gentle rise to the Low Steppes, much of which country is spinifex desert, 500 to 1000 feet above sea-level. A further gentle rise in the High Steppes leads to the mountains of the West Australian coast, and another strip of low-lying coastal land to the sea. The Great Central Plain is certainly Australia's most notable inland feature. Comparatively little of the rainfall over its vast extent ever reaches the sea by any known river system. Indeed the river systems as shown on maps leave a false impression as to the actual condition of things. The absence of rivers connecting the coast-line with the interior has already been noticed. In keeping with this is the solid outline of the coast generally. On the north and north-west some notable indentations lead to the Fitzroy, the Victoria, the Daley, and the Roper rivers.

The network of streams forming the tributaries of the Darling and Murray system give an idea of a well-watered country. The so-called rivers have running water only after heavy rains, and very few of these tributaries ever reach the main drainage line. Flood waters disappear often within a distance of a few miles, being absorbed by porous soil, stretches of sand, and sometimes by the underlying bed-rocks. The waters even of the Macquarie do not usually reach the Darling, but break up into innumerable gutters, and spread out over vast flats. In flood times only, the river overflows its banks, and flooding the flat country for miles around, reaches the Darling. Oxley went down the Lachlan, 1817, during one of these periods of flood, and the great plains appeared to him to be the fringe of a vast inland sea. As a matter of fact, they are an alluvial deposit spread out by the same flood waters. The great rivers of Australia, draining inland for the most part, carve out valleys, dissolve limestone, and spread out their deposit over the plains when the waters become too sluggish to bear their burden farther. From a geological standpoint, the Great Australian Plain and the fertile valley of the Nile have had a similar origin. Taking the Lachlan as one type of Australian river, we find it takes its rise amongst the precipitous and almost unexplored valleys of the Main Dividing Range. With the help of its tributaries it acts as a denuding agent for 14,000 square miles of country, and carries its burden of sediment westwards. A point is reached about 200 miles from the Dividing Range, where the river ceases to act as a denuding agent, and the area of deposition begins. But the river is still about 1000 miles from the sea. The Darling is reckoned amongst the longest rivers in the world, for it is navigable, part of the year, from Walgett to its confluence with the Murray, 1758 miles, and then to the sea, a further distance of 587 miles,—making in all 2345 miles of navigable water. But this gives no correct idea of the true character of the Darling, for it can hardly be said to drain its own watershed. From the sources of its various tributaries to the town of Bourke, the river may be described as draining a watershed. But from Bourke to the sea, 550 miles in a direct line, the river gives rather than receives water from the country it flows through.

The annual rainfall and the catchment area afford no data whatever as to the size of a river in the interior of Australia. In Europe it has been estimated that from 20 per cent. to 50 per cent. of the rainfall flows away in rivers. The discharge of the Darling River at Bourke does not amount to more than 10 per cent. of the rainfall of its catchment area. It was this startling fact which first led to the idea that, as the rainfall could not be accounted for either by evaporation or by the river discharge, much of the unaccounted-for 90 per cent. must in part sink into the ground, and in part be absorbed by some underlying bed-rock. All Australian rivers depend entirely and directly on the rainfall. They are flooded after rain, and in seasons of drought become dry water-courses. Springs which equalize the discharge of rivers by continuing to pour water into their beds, long after a rainy season, seem entirely absent in the interior. Neither are there any snow-fields to feed rivers, as in the other continents. More remarkable still, over large tracts of country the water seems disposed to flow away from, rather than to, the river-beds. As the low-lying plains are altogether an alluvial deposit, the coarser sediments accumulate in the regions where the river first overflows its banks to spread out over the plains. The country nearest the river receiving the heaviest deposit becomes in this way the highest ground, and so continues until a "break-away" occurs, when a new river-bed is formed, and the same process of deposition and accumulation is repeated. As the general level of the country is raised by successive alluvial deposits, the more ancient river-beds become buried, but being still connected with the newer rivers at some point or other, they continue to absorb water. This underground network of old river-beds underlying the great alluvial plains must be filled to repletion before flood waters will flow over the surface.

Outside the great alluvial plain there is a vast tract of country extending from the Musgrave Ranges west and north. This may be considered a plateau without any of the features of the plains. The bed-rock is nowhere far from the surface, thus forming a strong contrast with the great alluvial plain where the bed-rock is buried many hundred feet below the surface. Over the entire western half of Australia there is no leading drainage system, and we have here an area that is almost unique in the features of a continent. There is no high mountain, and probably over an expanse of 400,000 miles not a drop of the scanty rainfall ever reaches the sea.

The term desert applied to the Australian interior is somewhat misleading. Sandhills there are, and vast stretches of sandy country. But much of the so-called desert will support animal life to some extent. Sturt's "Stony Desert" is not at all what the name would suggest. Peculiar water-worn and glazed boulders cover much of the surface, but there is also grass, and in good seasons the "gibber land" disappears under a waving carpet of meadow. Part of Sturt's "Stony Desert" is now a sheep run, with one sheep to 10 to 12 acres, but growing excellent wool. Genuine desert exists in the spinifex country. On the outskirts are shady bauhinia trees and bright-looking desert-apple trees. The treacherous spinifex, too, looks fair enough from the distance, and often puts on a coat of enticing verdure when the plains and downs are parched and withered. It will grow almost on the surface of a hard rock, and in most parts of the desert the bed-rock is covered with but a shallow coating of soil. The result is like a thousand knitting-needles thrown into a confused kind of tangle, with all the points sticking upwards, and this tangle grows larger and more formidable every year, until a bush fire happily sweeps it away and a new growth starts. Much of this part of the continent is now known as the Australian Steppes. The Lower Steppes extend over an area corresponding mostly to the extent of the Cretaceous formation. Their prevailing aspect is characterized by flat and terraced hills, capped by desert sandstone, with stone-covered flats stretching over long distances. The country round Lake Eyre, where some of the land is actually below sea-level, comes under this heading. The Higher Steppes, as far as they are known, consist of Ordovician and Cambrian rocks, with an average elevation of 1500 to 3000 feet above sea level. Over this country water-courses are shown on maps. These run in wet seasons, but in every instance for a short distance only, and sooner or later they are lost in sand-hills, where their waters disappear and a line of stunted gum-trees (*Eucalyptus rostrata*) is all that is present to indicate that there may be even a soakage in these supposed rivers.



Stanford's Geog¹ Estab¹ London

SKETCH MAP OF AUSTRALIA.

Another notable feature of the interior is the so-called lake area, a district stretching to the north of Spencer Gulf. These lakes are expanses of brackish waters that spread or contract as the season is one of drought or rain. In seasons of drought they are hardly more than swamps and mud flats, which for a time may become a grassy plain, or desolate coast encrusted with salt. The country around is the dreariest imaginable, the surface is a dead level, there is no heavy timber and practically no settlement. Lake Torrens is sometimes 100 miles in length. To the north again stretches Lake Eyre, and to the west of Torrens Lake, Lake Gairdner. Some of these depressions are at, or slightly below, sea-level, so much so that a very slight depression of the land would connect much of the interior with the Southern Ocean.

Mountain ranges.

Along the entire coast there extends a succession of mountain ranges from Cape Howe to Cape York. These constitute a Cordillera stretching 1700 miles from north to south. Several points rise to heights of from 4000 to 5000 feet, mostly as isolated peaks. Towards the south-eastern corner of the continent the peaks come closer, clustering around

Mount Kosciusko (7328 feet), and are here known as the Australian Alps. North of Kosciusko the Main Divide merges into the Blue Mountains and Liverpool Range. The high land continues roughly parallel to the coast, and with generally diminishing altitude through Queensland to Cape York. Near the Queensland border Mount Lindsay rises to a height of 5500 feet. In the latitude of Brisbane the chain swerves inland; no other peak north of this reaches higher than Mount Bartle Frere in the Bellenden Ker Range (5438 feet). The Southern Ocean system of the Victorian Dividing Range hardly attains to the dignity of high mountains. An eastern system in South Australia touches at a few points a height of 3000 feet; and the Stirling Range, belonging to the south-western system of South Australia, reaches to 2340 feet. There are no mountains behind the Great Australian Bight. On the west the Darling Range faces the Indian Ocean, and extends from Point d'Entrecasteaux to the Murchison River. North of the Murchison, Mount Augustus and Mount Bruce, with their connecting highlands, cut off the coastal drainage from the interior; but no point on the north-west coast reaches a greater altitude than 4000 feet. Several minor ranges, the topography of which is little known, extend from Cambridge Gulf, behind a very much broken coast-line, to Limmen Bight on the Gulf of Carpentaria. Nothing is more remarkable than the contrast between the aspect of the coastal ranges of the north-east, and on the south-east of the continent. The higher Australian peaks in the south-east just look what they are, the worn and denuded stumps of mountains, standing for untold ages above the sea. Their shoulders are lifted high above the tree-line. Their summits stand out gaunt and lonely in an unbroken solitude. Having left the tree-line far behind him, nothing is visible to the traveller for miles around but barren peaks and torn crags in indescribable confusion. A verdure of herbage clothes the valleys that have been scooped from the summits downwards. But there are no perpetual snow-fields, no glaciers creep down these valleys, and no alpine hamlets ever appear to break the monotony. The mountains of the north-east, on the contrary, are clothed to their summits with a rich and varied flora. Naked crags, when they do appear, lift themselves from a sea of green, and a tropical vegetation, quite Malaysian in character, covers everything.

The absence of active volcanoes in Australia is a state of things, in a geological sense, quite new to the continent. Some of the volcanoes of the western districts of Victoria have been in eruption probably subsequent to the advent of the black-fellow. In some instances the cones are quite intact, and the beds of ash and scoriæ are as yet almost unaffected by denuding agencies. As late as 1859 an observer wrote in the *Quarterly Journal of the Geological Society* that, with one doubtful exception, Australia was a non-volcanic continent. The exception referred to is Mount Wingen. But even here there is nothing in the least resembling volcanic conditions. Some coal seams have been burning for years, giving out much smoke and steam. Mount Wingen was, in the eyes of the settlers, as it was in fact, a "burning mountain." Late in the Tertiary period vast sheets of lava poured from many points of the Great Dividing Range of eastern Australia. But it is notable that all recent volcanic action was confined to a wide belt parallel to the coast. No evidences of recent lava flows can be found in the interior over the Great Alluvial Plain, the Lower, or the Higher Steppes. Nor has the continent, as a whole, in recent times been subjected to any violent earth tremors; though in 1873, to the north of Lake Amadeus, in central Australia, Giles records the occurrence of earthquake shocks violent enough to dislodge considerable rock masses.

Barrier Reef.

The Barrier Reef forms the prominent feature off the north-east coast of Australia. Ranging for a length of 1200 miles, it is the greatest of coral reefs, ancient or modern. The channel between the reef and the coast is in places 70 miles in width and 60 fathoms deep. Flinders described the Barrier Reef in his *Voyage to Terra Australis;* and the Admiralty charts give much information as to soundings, &c. Our knowledge of the fauna of this richest of hunting grounds for the naturalist is very incomplete. Interest naturally centres in the coral polyp and its stony structure. Photographs have shown us what the physical features of the reefs are. The Hon. R. Abercromby's photographs, taken at Fiji, were probably the first; but Saville Kent, Agassiz, and other observers, have made us fairly well acquainted with the conditions presenting themselves on this great tract of growing land. The first point to strike a visitor to the Barrier Reef is the abundance of soft coral, or branching polyparies without a stony nucleus, and the abundance of nullipores and other plant-like organisms. Much of the pink and lilac coloured patches that catch the eye prove on examination to be nullipores or coralline seaweeds. There are patches of pebbles and boulders and fine sand everywhere, but each particle is part of a living thing. The patches of coral grow more or less after the manner of fairy rings—the outer edges flourishing and the inner dying and breaking into coral debris. The leading forms amongst the coral masses exposed at very low tides are the branching madrepores, the rounded masses of brain coral (meandrina), and porites. A field of madrepores is suggestive of miniature shrubbery, with plants, having the aspect of young pines. The coral is of every hue and colour, and not a little is added to the splendid scene by brilliant-hued fishes and bright and gaily-coloured sea-anemones (actinia), the latter often being more than 18 inches in diameter. The beautiful *distichopora coccinea* resembles somewhat the true red coral and is very abundant; but the red coral itself is not to be found. *Heliopora cærulea*, the beautiful blue coral, is not rare. This remarkable species has the stony framework of a bright blue, the colouring matter of most corals being confined to the "fleshy" covering. On the reef there is always to be found a great abundance of shells, living and dead. In appearance, the living specimens of many of the handsome species are disappointing, but the crabs, star-fishes, and great clam shells are conspicuous. Sea-cucumbers abound, so much so that the bêche-de-mer fisheries bring in more than £20,000 a-year. These interesting holothurians are collected by hand at low water, and sent to the Chinese markets after being cured by drying and smoking. "Rock oysters," too, are plentiful, and the blocks thrown up by the waves are soon encrusted with the well-known and delicate species *ostrea glomerata*.

There is nothing to be seen on or around the Great Barrier Reef that might be urged as a serious objection to Darwin's well-known subsidence theory. Any facts noted as inconsistent with prolonged steady subsidence might have been caused by a very slight upheaval. The few clear openings in the whole length of the outer rampart of the Great Barrier Reef are opposed to large estuaries. But being 30 to 90 miles away, they are not, in all probability, caused by fresh water from the land. Such breaks, however, are strong evidence in favour of subsidence. The old river channels, already referred to as being below sea-level, as well as the former land-connexion with New Guinea, all point to the conditions assumed by Darwin.

EXPLORATION.

By the end of the year 1873 the whole of the eastern portion of Australia had been explored, the unknown part of the continent being confined to the interior of West Australia and those districts of South Australia north of the Macdonnell Range and west of the overland telegraph line. Several attempts had been made to cross the colony of West Australia in the direction of east and west, but even Major Warburton's expedition, the most successful of these, had failed in the important particular of determining the nature of the country through which it passed. Major Warburton had virtually raced across from the Macdonnell Range in South Australia to the head waters of the Oakover river on the north-west coast, without allowing himself sufficient time to note the characteristics of the country. The next important expedition was differently conducted. John Forrest was despatched by the Perth Government with general instructions to obtain information regarding the immense tract of country out of which flow the rivers falling into the sea on the northern and western shores of West Australia. Leaving Yewin, a small settlement about lat. 28° south, long. 116° east, Forrest travelled north-east to the Murchison river, and followed the course of that river to the Robinson Ranges; thence his course lay generally eastward along the 26th parallel. Forrest and his party safely crossed the entire extent of West Australia, and entering South Australia struck the overland telegraph line at Peake station, and, after resting, journeyed south to Adelaide. Forrest traversed seventeen degrees of desert in five months, a very wonderful achievement, more especially as he was able to give a full report of the country through which he passed. His report destroyed all hope that pastoral settlement would extend to the spinifex region; and the main object of subsequent explorers was to determine the extent of the desert in the direction of north and south. Ernest Giles made several attempts to cross the Central Australian Desert, but it was not until his third attempt that he was successful. His journey ranks almost with Forrest's in the importance of its results and the success with which the appalling difficulties of the journey were overcome. Through the generosity of Sir Thomas Elder, of Adelaide, Giles's expedition was equipped with camels. It started on the 23rd May 1875 from Port Augusta. Working westerly along the line of the 30th parallel, Giles reached Perth in about five months. After resting in Perth for a short time, he commenced the return journey, which was made for the most part between the 24th and 25th parallels, and again successfully traversed the desert, reaching the overland telegraph line in about seven months. Giles's journeys added greatly to our knowledge of the characteristics of West and South Australia, and he was able to bear out the common opinion that the interior of Australia west of 132° E. long. is a sandy and waterless waste, entirely unfit for settlement.

The list of explorers from 1875 to 1900 is a long one; but after Forrest's and Giles's expeditions the main object ceased to be the discovery of pastoral country: a new zest had been added to the cause of exploration, and most of the smaller expeditions concerned themselves with the search for gold. Amongst the more important explorations may be ranked those of Tietkins in 1889, of W. Lindsay in 1891, of Wells in 1896, of Hubbe in 1896, and of the Hon. David Carnegie in 1896-97. Lindsay's expedition, which was fitted out by Sir Thomas Elder, the generous patron of Australian exploration, entered West Australia about the 26th parallel south lat., on the line of route taken by Forrest in 1874. From this point the explorer worked in a south-westerly direction to Queen Victoria Springs, where he struck the track of Giles's expedition of 1875. From the Springs the expedition went north-west and made a useful examination of the country lying between 119° and 115° meridians and between 26° and 28° south lat. Wells's expedition started from a base about 122° 20′ east and 25° 54′ south, and worked northward to the Joanna Springs, situated on the tropic of Capricorn and near the 124th meridian. From the springs the journey was continued along the same meridian to the Fitzroy river. The country passed through was mostly of a forbidding character, except where the Kimberley district was entered, and the expedition suffered even more than the usual hardships. The establishment of the gold-fields, with their large population, caused great interest to be taken in the discovery of practicable stock routes, especially from South Australia in the east, and from Kimberley district in the north. Alive to the importance of the trade, the South Australian Government despatched Hubbe from Oodnadatta to Coolgardie. He successfully accomplished his journey, but had to report that there was no practicable route for cattle between the two districts.

One of the most successful expeditions which traversed West Australia was that led and equipped by the Hon. David Carnegie, which started in July 1896, and travelled north-easterly until it reached Alexander Spring; then turning northward, it traversed the country between Wells's track of 1896 and the South Australian border. The expedition encountered very many hardships, but successfully reached Hall Creek in the Kimberley district. After a few months' rest it started on the return journey, following Sturt Creek until its termination in Gregory's Salt Sea, and then keeping parallel with the South Australian border as far as Lake MacDonald. Rounding that lake the expedition moved south-west and reached the settled districts in August 1897. The distance travelled was 5000 miles, and the actual time employed was eight months. This expedition put an end to the hope, so long entertained, that it was possible to obtain a direct and practicable route for stock between Kimberley and Coolgardie gold-fields; and it also proved that, with the possible exception of small isolated patches, the desert traversed contained no auriferous country.

GEOLOGY.

All the great formations familiar in the northern hemisphere are represented in the geology of Australia, which is in no way exceptional, either in the character of the rocks or in the zones of life that characterize them. The oldest rocks are of pre-Cambrian age, but little of their life-history is known. If differences, rather than resemblances, be dwelt on, there are many points concerning Australian geology in strong contrast to much that European geologists have been accustomed to. As has already been said, there are no volcanoes on the continent, and all over the vast interior there is a general absence of igneous rocks other than granites. Basalt is almost unknown except on an outside belt of the country roughly parallel to the coast. There are no solfataras, fumeroles, or geysers, and very few hot springs. There is no such thing as perpetual snow, even on the highest mountain, no glaciers or glacier lakes, and not a single mountain range with an Alpine structure. There is a notable absence of magnesian limestones, and phosphate-bearing rocks are unknown. There is an equivalent of the red sandstones, but no salt beds and no gypsum. There is evidence of glacial action in Permo Carboniferous times, during which period a great ice-sheet extended over a considerable portion of Australia, and evidences of *recent* glaciation at Mount Koscіusko are most pronounced. In the matter of folding we find the Australian, Cambrian, Silurian, and Devonian, all giving evidence of earth movements. The Silurian rocks in particular have been so folded and so intensely compressed that we usually find them over wide areas, vertical or highly inclined, and almost invariably with a meridional strike. All over the continent other formations laid down subsequent to those named are spread out in vast sheets, never showing a high angle of dip, and nowhere resting at any great height above sea-level. The Carboniferous rocks are also folded, but to a lesser degree than the Devonian, and of course in a degree not to be compared with the Silurian. The intense folding of the Silurian, taken together with the lithological character of its sediments, separates it at once from every other "formation" in the Australian geological column. So marked is this that throughout Australia rocks may be safely classed as Silurian if they show over considerable areas a "slaty" structure, a high angle of dip, and a meridional strike.

Against these facts may be placed others showing strong resemblance between Australian and European geology. The physical geography and the life of the Palæozoic and Mesozoic periods are in wonderful accord with those of other continents. The great development of coal in the Upper Palæozoic conforms to the northern conditions. The general types that characterize Cretaceous rocks are also present, plesiosaurs and chambered shells, such as ammonites, being as characteristic of the Australian Cretaceous as they are of the European. The forms of life, too, that occur in the Triassic of Europe, and even North America, find their counterpart here. In the shales round Sydney, which are admittedly of Triassic age, the remains of a giant labyrinthodon have been unearthed, and, associated with it, fishes and plants quite in keeping with forms familiar in the European Triassic.

In using such terms as "Permian" or "Eocene" there is reason to suppose that these periods in Australia might not have been quite synchronous with the European equivalents. Indeed it is not desirable to correlate too minutely Australian and European stratified rocks. We may even go further and say that it is improbable that any single life zone was laid down exactly at the same time that a similar life zone was being built up in northern Europe. One particular horizon in the Silurian is characterized by the interesting chain coral (halysites). No one would contend that the chain coral "reefs" in Australia and in Europe were exactly contemporaneous. But the relative position of the halysites zone in the geological column is the same in Europe and in Australia, and the physical conditions that surround the growing coral are precisely similar.

Some reference is made under the heading Fauna to the presence of "living fossils" in Australia. Certain characteristic types, long extinct in the northern hemisphere, still linger in the Australasian area. The Trigonia and the Heterodontus, the Marsupials, Myrmecobius, Ceratodus, and certain conifers and cycads are examples. One genus of cycad (Zamia) is exceedingly common over all the mountain and coastal regions of eastern Australia. It is a near ally of one of the most characteristic forms of the fossil flora of the Oolitic and Lias. In the well-known "dirt bed" of the Portland quarries, Dorsetshire, the stems of these cycads are to be found in great abundance.

The last feature of general import is the distribution of metamorphosed rocks. The lower series of the Palæozoic show a certain amount of metamorphism in conjunction with their highly inclined position. The Mesozoic rocks are much less altered from their original plane of deposition, and any metamorphism notable is of a limited and entirely local character. Certain sandstone beds of Cretaceous age have been much altered by the deposition of secondary silica. No great alteration approaching to metamorphism is known to have taken place amongst Tertiary rocks. Schistose structure is confined altogether to the lower Palæozoic.

PRINCIPAL AUSTRALIAN SEDIMENTARY FORMATIONS, WITH SOME CHARACTERISTIC FOSSILS.

CAINOZOIC, OR	POST-TERTIARY.	RECENT	Human bones and implements; remains of plants and animals of living species; Dinornis, Apteryx, Ornithorhynchus.
		PLEISTOCENE	Diprotodon, Macropus, Thylacoleo, Thylacinus, Nothosaurus, Megalania, Dromornis, Echidna, Meiolania, Palorchestes, Dromæus, Mytilus, Siphonalia.
	TERTIARY.	PLIOCENE	Phascolomys, Procoptodon, Macropus, Thylacinus, Thylacoleo, Diprotodon. Spondylostrobus, Wilkinsonia, Penteune, and other fossil fruits, in old "leads."
		MIOCENE	Nassa, Marginella, Ancilla, Cancellaria, Natica, Leiopyrga, Nucula, Trigonia, Chione, Meroe, Tellina.
		EOCENE	Flabellum, Placotrochus, Terebratulina, Cucullæa, Corbula, Nassa, Voluta, Marginella, Aturia, Murex (upwards 30 sp.), Triton, Mitra, Fusus, Natica, Cerithium.
MESOZOIC, OR SECONDARY.		CRETACEOUS	Ichthyosaurus, Plesiosaurus, Ammonites, Belemnites, Cidaris, Avicula, Trigonia, Baculites, Cimoliosaurus, Mactra, Inoceramus, Maccoyella.
	TRIAS-JURA.	JURASSIC	Taxites, Tæniopteris, Thinnfeldia, Podozamites, Sphenopteris, Leptolepis, Coccolepis, Aphnelepis.
		TRIASSIC OR TRIAS-JURA	Tæniopteris, Sagenopteris, Cycadopteris, Alethopteris, Macrotæniopteris, Sphenopteris, Pecopteris, Jeanpaulia, Podozamites, Equisetum, Oleandridium, Otozamites, Schizoneura, Ginkgo, Zamites, Thinnfeldia, Phyllotheca, Platyceps, Unionella, Estheria, Tremanotus, Palæoniscus, Unio, Myriolepis, Mastodonsaurus, Pristisomus, Cleithrolepis.

PALÆOZOIC, or PRIMARY.	PERMO-CARBONIFEROUS	Glossopteris, Phyllotheca, Vertebraria, Sphenopteris, Annularia, Spirifer, Pachydomus, Productus, Orthoceras, Conularia, Martiniopsis, Eurydesma, Platyceras, Leaia, Gangamopteris, Aviculopecten, Notomya, Sanguinolites.
	CARBONIFEROUS	Rhacopteris, Lepidodendron, Calamites, Archæopteris, Sigillaria, Loxonema, Euomphalus, Spirifer, Orthis, Leptæna, Phyllotheca, Fenestella.
	DEVONIAN	Lepidodendron, Cyclostigma, Spirifer, Rhynchonella, Atrypa, Orthis, Orthoceras, Asterolepas, Pteronites, Murchisonia.
	SILURIAN	Atrypa, Pentamerus, Halysites, Graptolites, Phacops, Bronteus, Calymene, Cyathophyllum, Spirifera, Didymograptus, Lingulocaris, Lingula, Mucophyllum, Stromatopora, Favosites, Heliophyllum, Phillipsastrea, Rhizophyllum, Columnaria, Petraia, Lichas, Syringopora, Cyclonema, Bellerophon, Palæaster, Niso, Trochus, Asaphus, Beyrichia, Cyphaspis.
	CAMBRIAN	Conocephalites, Dolichometopus, Dikelocephalus, Dinesus, Olenellus, Salterella, Orthisina, Leperditia.

TABLE, SHOWING THE GENERAL SUCCESSION OF AUSTRALIAN STRATA.

PERIOD.	SYSTEM.	SOME TYPICAL EXAMPLES.
POST-TERTIARY.	RECENT	Raised beaches.—Victoria and West Australia have sand loams for forming these.
	PLEISTOCENE	Alluvial flats and great plains of the interior. Raised beaches of the north-west coast, Tasmania. Large area in the south-east of South Australia.
CAINOZOIC, or TERTIARY.	PLIOCENE	Limestone creek beds, south-west Victoria, containing about 80 per cent. of living molluscs. Volcanic ash beds of Mount Gambier. Mammaliferous sandy clays containing diprotodon, &c. Mammaliferous cave deposits of New South Wales and Victoria; freshwater limestones of the Geelong district. Newer basalts at Werribee, Geelong, and Camperdown, Victoria.
	MIOCENE	Marine sands of the Dry Creek and Croydon bores, South Australia. Oyster beds of the Murray river cliffs and Aldinga Bay, South Australia. Calcareous sands and clays of Jemmy's Point, Gippsland, and the upper beds at Murray Creek, near Hamilton, West Victoria.
	EOCENE	Generally—limestones, clays, and sands from the Snowy river, Gippsland, to the Great Australian Bight; also from Geraldton to Shark Bay, Western Australia; and Table Cape, Tasmania (all marine). Plant beds of Emmaville, New South Wales. *No marine beds of Eocene, Miocene, or Pliocene age are known east of the Main Dividing Range in New South Wales or Queensland.*
MESOZOIC, or SECONDARY.	CRETACEOUS	Pending a fuller knowledge of our Secondary rocks, some geologists merely divide them into Upper and Lower Mesozoic. Upper Cretaceous.—Desert sandstone of Queensland. Lower Cretaceous.—Rolling Downs formation of Queensland. Artesian water-bearing beds of north-western New South Wales. Kennedy Range and Gascoyne river, West Australia.
	JURASSIC	Beds with fossil fish, Talbragar river, New South Wales. Oolitic limestone of Champion Bay district, West Australia.
	TRIASSIC, or TRIAS-JURA	The Hawkesbury sandstones and associated shales of New South Wales. Lower Mesozoic rocks of the Clarence river. The Ipswich and Burrum beds of Queensland with *Tæniopteris*. The Upper Coal Measures of Tasmania, and the Collie Creek Coal Measures of West Australia are considered to be of Mesozoic age.
PALÆOZOIC, or PRIMARY.	PERMO-CARBONIFEROUS	Coal Measures of New South Wales, Newcastle, Illawarra, and Lithgow, with *Glossopteris*. Upper and Middle Bowen river formations, Queensland. Collie river and Irwin river, West Australia. Tasmanite beds, Mersey and coast about the estuary of the Derwent, Tasmania.
	CARBONIFEROUS	Port Stephens district, New South Wales. Gympie, Lower Bowen, and Star formations, Queensland. Also the Lower Coal Measures of Tasmania.
	DEVONIAN	Mount Lambie sandstones, Rydal, New South Wales. Avon river and Mount Tambo beds, Victoria. Burdekin beds, Queensland. Sandstones and grits, Kimberley, West Australia. Fingal slates, Tasmania.
	SILURIAN	Highly-inclined clay slates and talcose slates, New South Wales, South Australia, and West Australia and Victoria. Graptolite beds of Victoria. Yass and Molong limestones, New South Wales. "Larapintine" limestones, Macdonnell ranges. Queen river schists and slates, and the Gordon river group, Tasmania.
	CAMBRIAN	*Olenellus* and *Salterella* beds of Kimberley, West Australia. Ardrossan beds of South Australia. Magog and Carolina creek groups, Tasmania. Yorke's Peninsula series, South Australia. Kimberley, West Australia. Heathcote, Victoria.
	PRE-CAMBRIAN	Quartzite and some metamorphic rocks of Tasmania. Mount Lofty Ranges, South Australia.

Cambrian.

Of the seven sub-kingdoms of living things, no less than five are represented in the Australian Cambrian. If we except vertebrates, we have therefore at the very dawn of life representatives of the animal world as we know it to-day,—types which are in no sense embryonic. We cannot here, any more than elsewhere, work back far enough to get near to the beginnings of life. The animals on the Cambrian sea-shores were graded and grouped no less exactly and definitely than the invertebrate fauna of the present coast-line. Mammals, birds, reptiles, and fishes are, of course, absent; but it must strike one as remarkable that foraminifera, sponges, corals, hydrozoans, entomostraca, trilobites, brachiopods, lamellibranchs, gasteropods, and pteropods, should be present in that far-off epoch pretty much as we see them to-day. Cambrian rocks are known in Yorke's Peninsula, South Australia, and near Leigh's Creek, 300 miles to the north of Adelaide. Cambrian rocks have been described in the Kimberley district of West Australia containing such world-wide forms as *Salterella* and *Olenellus*. The Macdonnell Ranges of Central Australia are considered also of Cambrian age, and, like all the Australian Cambrian, are of marine origin. Some of the Cambrian beds were laid down in shallow waters, as ripple-marked quartzites and current-bedded sandstones are known to occur. No contemporaneous igneous rocks are known. The Cambrian shows evidence of much folding, and it is evident that the earth movements giving rise to the folds took place before the deposition of the succeeding Silurian. The Macdonnell Range, usually regarded as Cambrian, consists of conglomerates, limestones, and slates, and these conglomerates are the first evidence of the existence of any land in Australia.

Silurian.

The Silurian system is well represented over Australia. Quite one-thirtieth of the area of the continent is covered by rocks of this age. In the colony of Queensland, however, the Silurian is not developed to any considerable extent. The Australian Silurian consists of sandstones, mud-stones, conglomerates (rare), "slates," and limestones. Over a great area of the country highly inclined mud-stones are known as Silurian "slates." The cleavage of these rocks corresponds to the bedding planes, and they are, therefore, not true slates. Nowhere has the Australian Silurian been subjected to such intense metamorphism as to develop cleavages across the deposition planes. The Silurian beds have been tilted, folded, and broken; but the conditions necessary for the production of rocks resembling, say, the Bangor slates, were not present. The mud-stones of Victoria have yielded an abundance of Graptolites, and these interesting fossils have also been found in New South Wales. The richest fauna, however, has been discovered in the limestones. European forms, made familiar by text-books, are well represented, as, for instance —*Halysites*, *Favosites*, *Syringopora*, *Phillipsastrea*, amongst the corals; *Phacops*, *Bronteus*, and *Calymene*, amongst the trilobites. *Receptaculites* is also known, together with *Pentamerus*, and a number of Spirifers. So far as is known, the Silurian beds are marine. No contemporaneous igneous rocks have been discovered. In Victoria the Upper and Lower Silurian have an aggregate thickness of 35,000 feet. In New South Wales a section has been measured at Molong showing a thickness of 3000 feet. The "slates" of Silurian age are often seen to rest directly on granite, their bedding planes standing vertically and rising directly from the granite. The granite is not, therefore, the original bed-rock on which the slates were laid down. There is abundant evidence to show that much of the granite was intruded amongst the "slates" after the latter were left highly inclined by intense folding. These granites are therefore younger than Silurian, and, as they do not intrude on the Carboniferous higher up in the series, they are probably of Devonian age.

Some interesting caves have been discovered in the limestones of this age. The Australian black-fellow has left us no history in connexion with them. Certain rock shelters have been used by the aboriginals, but of the limestone caves they evidently made no use. The living aboriginal avoids even their vicinity. The Wellington caves of New South Wales have been eroded through limestones of Silurian age. Breccias accumulated through openings from the surface, and yielded a series of most interesting giant marsupials, first drawn attention to by Sir Richard Owen. In fact, the whole importance of these caves lies in the scientific value attached to the fossils referred to. From a scenic point the caves are uninteresting. The Jenolan caves of New South Wales are also eroded from limestones of the same age. They have yielded no fossils of especial interest, but are widely known for their beauty. Geologically, the existence of the caves depends on the fact that a bar of limestone runs almost directly across a deeply eroded valley,—water, the giant sculptor of mountains, having found it easier to make for itself a passage by dissolving the limestones than by eroding them to the valley level.

Devonian.

In Australia there is a great development of stratified rocks up to 23,000 feet in thickness, unconformable to the older Silurian and the overlying Carboniferous. The life of the period is also clearly distinct from that of the preceding and the succeeding rocks. Here for the first time in the geological record we meet with contemporaneous igneous rocks. The Snowy river porphyries of Victoria and certain felsites in the Braidwood district, New South Wales, must be considered the results of volcanic outbursts in Devonian times. In Queensland, Devonian rocks quite 20,000 feet in thickness have been measured, forming one unbroken series. Devonian rocks are developed largely in Western Australia. There is one belt 200 miles long, from the Saw Ranges to the Lubbock Range. Interbedded igneous rocks, breccias, and ash-beds are known, up to 100 feet in thickness. In the Kimberley district of the same colony there are grits, conglomerates, and limestones and slaty shales of Devonian age, 1100 feet in thickness. The earliest land plant indicating a land flora for Australia is *Dicranophyllum Australicum* from the middle Devonian of Queensland. Remnants of old land areas which supported a land flora are also preserved near Mansfield in Victoria, also near Twofold Bay, and at Rydal in New South Wales. Rocks with a thickness of quite 10,000 feet are developed at Rydal (New South Wales). They contain the well-known fossils, *Spirifera disjuncta* and *Rhynchonella pleurodon*, occurring mostly in quartzites. The series is made up for the most part of reddish and purple shales, mud-stones, grit, and conglomerates. These show a strong unconformability with the underlying Silurian. The occurrence of *Lepidodendron* is remarkable, being found as it is exactly in the same horizon as the Spirifer named.

Carboniferous.

The Carboniferous of Europe is remarkable for the great development of workable coal-seams in the series. In Australia the greatest accumulation of coal is found in a subsequent series of rock known as the Permo-Carboniferous. The Australian Carboniferous is characterized by such forms as *Lepidodendron*, *Rhacopteris*, *Cordiates*, *Archæopteris*, *Sphenopteris*, and *Palæoniscid* fish, and also by well-marked marine shells. The rocks are therefore partly marine and partly fresh-water, and evidence of contemporaneous igneous activity is left by a great variety of rocks ranging from felsites to basalt. Carboniferous beds rich in fossil plants can be traced from Queensland through New South Wales. The Carboniferous rocks of Queensland are conveniently divided into (1) Gymple series, which has been measured up to 21,000 feet in thickness, on the Hodgkinson goldfield. The chief fossils are the marine forms—*Protoretepora ampla*, *Productus cora* and *Martinia subradiata*—associated with *Lepidodendron*; (2) the Star formation, made up of slates, conglomerates, sandstones, and a thin band of limestone—the whole reaching up to a thickness of 1353 feet. *Lepidodendron* is also abundant, and *Cyclostigma*, with the marine forms, *Phillipsia dubia* and *Rhynchonella pleurodon*. The Carboniferous rocks of West Australia consist of limestone beds interbedded with shales, layers of gypsum, and traces of rock salt 1000 to 1300 feet in thickness, and a series of freshwater sandstones, with a thickness of 1800 feet.

The Silurian, Devonian, and Carboniferous, with their associated igneous rocks, are the sources of all the metalliferous deposits in Australia, the alluvial leads being of course derived from the wearing down of these formations. The well-known Mount Morgan mine may perhaps be noted as an exception, for we have here a geyser deposit, of Upper Mesozoic or Tertiary age, in a Permo-Carboniferous area. No rocks newer than the Carboniferous are known to have had metalliferous deposits in the shape of *lodes* formed amongst them.

Permo-Carboniferous.

Permo-Carboniferous is a term originally proposed by Mr Robert Etheridge, jun., for a formation "distinguished by a copious marine fauna partaking of a Carboniferous and Permian nature, and a flora from which lycopodiaceous plants were almost entirely absent." Anyone familiar with the Carboniferous rocks of Europe will remember that the most characteristic fossil plant is *Lepidodendron*. This is absent in the Coal Measures of eastern Australia; and in its place we find plants, and one form in particular, with quite a Mesozoic aspect. The fern referred to is *Glossopteris*. This beautiful fossil plant is found associated with workable Coal Measures over great areas of the continent. The Permo-Carboniferous rocks of Eastern Australia are quite 10,000 feet in thickness. The lower beds contain coarse conglomerates in great abundance and a very distinctive marine fauna. The upper beds are made up for the most part of finer materials and are of freshwater origin. The whole series is thus divided in the type district, Newcastle, as follows:—

PERMO CARBONIFEROUS	UPPER COAL MEASURES	The seams of coal worked at Newcastle belong to the Upper Coal Measures. The best known in the NEWCASTLE COAL MEASURES are, in descending order—(1) Parbury's seam; (2) Great Northern seam; (3) Burwood seam; (4) Dirty seam; (5) Yard seam; (6) Borehole seam. *Glossopteris* abundant. The DEMPSEY SERIES, 2000 feet in thickness, separate these coal seams from the underlying TOMAGO COAL MEASURES.
	UPPER MARINE SERIES	The UPPER MARINE BEDS are about 5000 feet in thickness. The following divisions are recognized in descending order:—(1) Beds with Crinoids and [illegible]; (2) beds with abundance of Spirifera; (3) Muree rock; (4) conglomerates.
	LOWER COAL MEASURES	GRETA COAL MEASURES, with no marine shells. Fossil plants abundant. *Glossopteris* common.
	LOWER MARINE SERIES	The LOWER MARINE SERIES is about 2000 feet in thickness. *Eurydesma cordata* is characteristic.

Quite fifteen seams of workable coal, with an aggregate thickness of 150 feet, have been opened up around Newcastle, New South Wales. It has been estimated that at the present rate of consumption the known coal beds would last 3000 years. The same series with similar fossils is known to occur in West Australia, Tasmania, and Queensland. A considerable amount of volcanic activity manifested itself at many points over what is now East and West Australia in Permo-Carboniferous times.

Jurassic.

Jurassic beds are said to underlie the Cretaceous to the north of Champion Bay, West Australia. Oolitic limestones, grits, sandstones, and clay ironstones make up the series. Some fossils have been described from Shark Bay, where they occur in ferruginous and variegated limestones, clays, and ironstones, not unlike rocks of the same age occurring in England. These interesting stratified rocks are all of marine origin. In other parts of Australia freshwater deposits containing abundant plant remains are classed as Jurassic. A remnant of rocks of this age occurs near Gulgong (New South Wales). Here some yellow ferruginous shales were found to contain abundant fish remains. The fish belonged for the most part to the *Leptolepidæ*, and on the same slab could be seen land-shells, and impressions of *Tæniopteris*. The fossiliferous shales are *in situ*, being laid down in an eroded hollow in the Hawkesbury sandstone.

Triassic.

The type district for Triassic rocks in Australia is immediately around Sydney. Here the rocks are divided into three groups: (1) Wianamatta shales, 700 feet; (2) Hawkesbury sandstone, 1000 feet; (3) Narrabeen shales, 1600 feet. The whole series is characterized by the absence of marine fossils and an abundant and decided Mesozoic flora. Fish remains have also been discovered. Much of the beauty of Sydney as a city is due to the excellent building material supplied by the Hawkesbury sandstone. Ascending from Permo-Carboniferous to Triassic rocks we at once lose the characteristic Coal Measures fossil, *Glossopteris*. Quite another fern characterizes Triassic rocks—*Tæniopteris*. In searching for artesian water in Western New South Wales, *Tæniopteris* beds have been discovered (underlying Cretaceous). After boring through these beds abundant supplies of artesian water were struck. The presumption, therefore, is that Triassic rocks, and not Cretaceous, are the source of artesian water, if not in Queensland, certainly in New South Wales.

Trias-Jura.

Queensland has a great series of coal-bearing rocks, known as the Burrum formation. The lower Burrum coalfield extends along the eastern coast-line from Point Cartwright on the south, to Littabella Creek on the north, and stretches inland for an average distance of 25 miles. Its area is estimated at 3000 square miles. The Coal Measures of this formation contain several workable coal-seams, of excellent quality for steaming purposes. No marine fossils have been discovered, but plants of the usual Mesozoic aspect are plentiful. Newer than the Burrum is the Ipswich, also classed as Trias-Jura. This formation occupies an area of quite 12,000 square miles in the south-eastern corner of Queensland. The Ipswich formation contains excellent coal-seams. These beds contain no marine fossils, the whole being laid down under freshwater conditions. There is an abundant flora, prominent forms being—*Equisetum*, *Sphenopteris*, *Thinnfeldia*, and *Tæniopteris*; but *Glossopteris*, so characteristic of the Newcastle Coal Measures, is absent. The Collie Creek Coal Measures of West Australia may be provisionally classed here. There is an important series of rocks in Tasmania, undoubtedly of Mesozoic age, composed mainly of variegated sandstones, shales, and blue and white clays. The series frequently contains seams of coal of good thickness and fair quality. There are no marine fossils, but a great abundance of plant remains with a decidedly Mesozoic aspect. Mr R. M. Johnstone considers that these beds probably cover the whole period from the close of the upper Palæozoic Coal Measures to the beginning of the Tertiary period. Some of these beds are probably of the same age as the Trias-Jura of Queensland. Certain beds in Victoria, about Cape Paterson, Barabool Hills, and a series known as the Bellarine beds, consisting of sandstones, coal, and carbonaceous shales, may belong to this series. They contain an abundant fossil flora, but no marine fossils. The leading forms are *Tæniopteris*, *Alethopteris*, and *Zamites*. These rocks occupy four distinct areas, and contain all the known coal-bearing rocks in Victoria. They cover, at least, 4000 square miles.

Cretaceous.

The Cretaceous rocks cover an immense area in New South Wales, Queensland, North, West, and Central Australia. They may be grouped into three series—the lower, developed chiefly in Western Australia; the middle, in North-Western New South Wales; and the upper, in Queensland and over Central Australia generally. The Upper Cretaceous, to which belongs the widely-spread formation known as desert sandstone, must have covered more than one-fourth of the whole continent. This sandstone, it has been remarked, is a monument of the power of denudation. It is now found only in isolated fragmentary table-lands. Taken as a whole, the desert sandstones vary greatly in composition, in texture, and in general appearance; but individual beds preserve their characteristics over very large areas. In Western New South Wales deposits of excellent opal have been found in marls of Cretaceous age. These marls are undoubtedly of marine origin. The opal is found filling in seams in the marls; but reptilean bones, wood, gasteropod shells and belemnites are also found converted into noble opal of first quality. The silica of the opal is probably derived from diatomaceous and radiolarian tests in the marls. The Lower Cretaceous rocks of Queensland are believed to be sources of artesian water. The Cretaceous rocks of New South Wales were also supposed to yield artesian water. More recent investigation has shown that, although the artesian bores are in many instances put down through Cretaceous rocks, the water-bearing strata belong to the underlying Triassic. The lower beds form the country known as the Rolling Downs. They consist of shales, Cretaceous sandstones, with no great development of Calcareous rocks or limestones. The presence of ammonites and belemnites indicates a marine origin for these beds. Cretaceous rocks cover probably more than 300,000 square miles. It is estimated that the desert sandstone at one time covered an area of 500 square miles, but has now been reduced by denudation to isolated table-lands. The most striking feature in connexion with the Queensland Cretaceous rocks is their horizontal bedding, and their occurrence in flat-topped, step-cut hills. The desert sandstone plains present a most desolate appearance, and form some of the poorest, the driest, and the most inhospitable territory of the continent. The Cretaceous rocks have been very little disturbed by the intrusion of the igneous materials.

Tertiary.

Marine beds of Eocene, Miocene, and probably Pliocene age occupy a large extent of country on the southern shores of the continent, extending from Gippsland away round to West Australia. Marine Tertiary must cover at least 20,000 square miles, and near Melbourne very considerable thicknesses of Eocene rocks have been found. The Croydon boring near Adelaide shows a thickness of fully 2300 feet of pre-Pliocene Tertiary strata. They reach inland to the south-western corner of New South Wales, where they are over-lain by alluvial deposits of Pleistocene age. Tertiary marine beds are also known on the north coast of Tasmania. Quite a different set of beds occur inland in New South Wales, Victoria, and Queensland. There are also rocks of Tertiary age, but they were laid down under inland and freshwater conditions. Some of the beds contain in abundance fossil plants strongly suggestive of some of the earlier Tertiary European flora. Sufficient is known now of the marine Tertiary beds of Australia to separate them into Eocene, Miocene, and Pliocene.

Eocene.—Eocene rocks are particularly rich in fossils—the Eocene beds of Aldinga and Adelaide being notable for gasteropods, lamellibranchs, echinoderms and corals. The Eocene beds at Muddy Creek, West Victoria, are even more prolific, 649 species of molluscs having been recorded. The Eocene beds are made up of clays, calcareous limestones, sandstones, bands of pebbles and grits and shelly limestones. The proportion of living species of mollusca in Australian Eocene rocks nowhere exceeds 3½ per cent., and the percentage is usually under two.

Miocene.—Miocene beds occur overlying Eocene rocks in the river Murray cliffs. At Aldinga Bay and Hallet's Cove, on the east side of St Vincent Gulf, Miocene beds rest directly on the Eocene—in both cases the newer rocks lying on the eroded surface of the older. At Muddy Creek, in Western Victoria, Miocene beds are also found overlying the Eocene, and near the Gippsland Lakes they flank an Eocene escarpment. The Australian Eocene contains 15 per cent. of living forms. The rocks consist of blue clays, mottled sands, calciferous sandstones, and sandy clays.

Pliocene.—Bores put down at Dry Creek in South Australia show the existence of strata with a fauna comprising 210 species, of which 150 are gasteropods, and 60 lamellibranchs. As the beds contain about 27 per cent. of living species, Professor Tate provisionally called these beds Older Pliocene, "though in this case the percentage system does not fully indicate the strong modern facies exhibited in this collection of fossils." The Croydon bore, near Adelaide, passed through 406 feet of stratified rocks, some of which are of Pliocene Age. Some beds occurring in the south-west of Victoria, at Limestone Creek, have yielded an abundant fauna—the proportions of recent forms being 80 per cent.—and are considered late-Pliocene. These rocks are wholly marine. Towards the centre of the continent, however, a totally different set of beds were laid down, mostly of lacustrine or alluvial origin. In Pliocene times much of the present arid interior was a well-watered country, supporting a luxuriant vegetation. The fauna of this period included many animals of astonishing proportions and most remarkable structural characteristics. These larger forms were all marsupials, and are now extinct. Species of diprotodon, nototherium, phascolomys, macropus, and protemnodon must have been plentifully distributed. To account for the existence of such huge herbivores, we must suppose a well-watered country, with a luxuriant vegetation, in place of the present desolate and arid region of Central Australia. The lakes of the interior of Australia, which are for the most part simply dead levels of white salt, must in Pliocene times have been magnificent sheets of water, set amidst rich tropical forests. Herds of giant marsupials, birds as large as the New Zealand moa, saurians 15 feet in length (*Nothosaurus*), and gigantic monitors tenanted the country. Amongst the marsupials, *Diprotodon* was the most notable, with a head 3 feet in length. A kangaroo, with a skull as large as that of an ox, (*Palorchestes azael*) was the largest known member of the kangaroo family. *Nototherium*, another great marsupial, almost rivalled the diprotodon. The remains of a large extinct wombat, equalling a tapir in size, have also been described. Associated with these was a skull with extraordinary adze-shaped teeth. Their long chisel-like form suggested the name *Sceparnodon*. There was also an animal (*Koalemus*) probably the ancestral form of the living "native bear." The existing bear is an animal about 2 feet long, with a body made to look more clumsy by the almost complete absence of a tail. The bear of to-day weighs about 20 lb. The bear of Pliocene and post-Pliocene times was a similar animal, more clumsy and more unwieldy, if such can be pictured. The fossil form was many times as large as the "native bear," and would turn the scale at 500 to 600 lb. The *Sarcophilus*, or "Tasmanian devil," is now extinct on the mainland, but its remains are very common in Pliocene and post-Pliocene drifts, from Victoria to Queensland. Another animal that lived in the days of the diprotodon, is *Thylacoleo*, a gigantic ally of the phalangers. The skull measured nearly a foot in length. Various theories have been advanced to explain the extinction of forms so vast and varied. The drying up of the lacustrine area had no doubt much to do with the change. Pliocene conditions continued into post-Pliocene times. The absence of marine beds of this age over the continent makes our subdivisions of this portion of the geological record somewhat arbitrary. The great alluvial plains are the work of rivers in post-Pliocene times, and much of the drifts and "leads" containing gold and tin-stone are of the same age. All the evidences of the presence of man are confined to recent deposits. But although, geologically considered, man is a recent arrival, yet measured in years his existence is one of vast antiquity on the Australian continent.

Plutonic and volcanic.

Granites may be said to be well represented, and are almost everywhere associated with the older stratified rocks. Over the whole of the interior, there is a notable absence of basalt or recent lavas, and even of such intrusive rocks as diorites. Vast tracts of Cretaceous and Tertiary country show no igneous rocks for many hundreds of square miles. The Koscinsko plateau consists for the most part of gneissic granite, cut through sparingly by igneous dykes, and in one instance, by what seems to be a volcanic neck. The bulk of the Australian granites seem to have been intruded into Silurian and Devonian, and perhaps even into Carboniferous, but they are older than the Permo-Carboniferous. The first manifestations of igneous outpourings are noted as having occurred in Devonian times. In the succeeding Carboniferous and Permo-Carboniferous, volcanic activity was also very manifest, and is shown by many hundred feet of interstratified volcanic products. In Triassic times there is very little sign of volcanic action. The Cretaceous period, too, was one of quietude. The next outburst of volcanic fires occurred in the Tertiary, and this continued down almost to the advent of the aboriginals. In the western district of Victoria some remarkably fine craters remain quite fresh and very little cut into or denuded by atmospheric agencies. Here quite eight of the points of eruption have been counted which poured out the floods of basalt known in Victoria as newer volcanic.

As regards the distribution of recent volcanic rocks, New South Wales shows excellent types of trachytes in the Warrumbungle mountains, and also in the Canoblas, a point of eruption near Orange, about one hundred miles west of Sydney. Along the slopes of the Main Dividing Range, there is much basalt of the typical basic character. Many of the "leads" that have yielded so much alluvial gold are old river-beds buried under this basalt. Flat-topped basalt-covered hills are a marked character of the western slopes of the eastern Dividing Range. These are remnants of lava streams that flowed from long extinct, but geologically recent, volcanoes. Basalt in these instances filled the old valleys, and the surrounding country rock being worn away, the basalt now remains above the general level. Thus the lines of the old rivers, once the lowest part of the country, now stand out as the highest ground. Water-worn pebbles, sand, and shingle—in other words, old river-drifts—are invariably found under these cappings. A leucite basalt of Tertiary age occurs in three different localities in New South Wales. No nephelin basalts have been discovered anywhere on the continent. Serpentines are well represented, in one case evidently derived from an olivine-bearing rock. Basaltic dykes are extremely common, cutting up through the whole geological series as high as the Triassic. In formations of a later age, dyke rocks are not so common. Rhyolites and true Andesites are rare as products of recent volcanic action in Australia.

FLORA.

To understand the distribution of plants in Australia, one must always bear in mind that the central valleys and plateaux are surrounded by physical conditions totally different from those prevailing on the coastal plains, and that the northern part of the continent has been invaded by a number of plants characteristically Melanesian. This element was introduced *viâ* Torres Strait, and spread down the Queensland coast, and also round the gulf of Carpentaria, but has never been able to obtain a hold in the more arid interior. Judging by the plants alone, and to a great extent by the animals, nobody could tell, when in a Queensland coast-jungle, whether he were in Australia or New Guinea. Travellers often describe the wonderful wealth of plant life in the eastern coast-line, but this must not be taken as indicating the nature of the flora inland in the same latitude. In the interior there is little change in the general aspect of the vegetation, from the Australian Bight to the region of Carpentaria when the exotic element begins. Behind the luxuriant jungles of the Queensland coast, once over the Main Range, we find the purely Australian flora with its apparent sameness and sombre dulness. Physical surroundings rather than latitude determine the character of the flora. The contour lines showing the heights above sea-level are the directions along which species spread to form zones. Putting aside the exotic vegetation of the north and east coast-line, the Australian bush gains its peculiar character from the prevalence of the so-called gum-trees (*Eucalyptus*) and the acacias, of which last there are 300 species. But the eucalypts above all are everywhere. Stunted eucalypts fringe the tree limit on Mount Kosciusko, and the soakages in the parched interior, which pass on maps for rivers, are indicated by a line of the same trees, stunted and straggling. Over the vast continent from Wilson's Promontory to Cape York, north, south, east, and west—where anything can grow—there will be found a gum-tree. The eucalypts, so typical of the Australian bush, are remarkable for the oil secreted in their leaves, and the large quantity of astringent resin of their bark. This resinous exudation (Kino) somewhat resembles gum, hence the name "gum" tree. It will not dissolve in water as gums do, but it is soluble in alcohol, as resin usually is. Many of the gum-trees throw off their bark, so that it hangs in long dry strips from the trunk and branches, a feature familiar in "bush" pictures. The bark, resin, and "oils" of the eucalyptus are well known as commercial products. As early as 1866, tannic acid, gallic acid, wood spirit, acetic acid, essential oil and eucalyptol, were produced from various species of eucalyptus. The genus eucalyptus numbers more than one hundred and fifty species, and provides some of the most durable timbers known. The iron-bark of the eastern uplands is well known (*Eucalyptus sideroxylon*), and is so called from the hardness of the wood, the bark not being remarkable except for its rugged and blackened aspect. Samples of this timber have been studied after forty-three years' immersion in sea water. Portions most liable to destruction, those parts between the tide marks, were found perfectly sound, and showed not the slightest sign of the ravages of marine organisms. The well-known Jerrah (*Eucalyptus marginata*) of West Australia is one of the most durable of timbers; 14,000 square miles of country are covered with this species. This tree has been known to grow to 10 feet in diameter and 120 feet in height. The timber is nearly impervious to the attacks of the teredo. There is good evidence to show that, exposed to wear and weather, or placed under the soil, or used as submarine piles, the wood remained intact after nearly fifty years' trial. The following figures show the high density of Australian timber:—

Australian Timber.	Specific Gravity.	Australian Timber.	Specific Gravity.
Jarrah	1·12	Tallow wood	1·23
White iron-bark	1·17	Mahogany	1·20
Red iron bark	1·22	Grey gum	·917
Forest oak	1·21	Red gum	·995
European Timber.	**Specific Gravity.**	**European Timber.**	**Specific Gravity.**
Ash	·753	Ebony	1·19
Beech	·690	British oak	·99
Chestnut	·535		

Various "scrubs" characterize the interior, differing very widely from the coastal scrubs. "Mallee" scrub occupies large tracts in South Australia and Victoria, covering probably an extent of 16,000 square miles. The mallee is a species of eucalyptus growing 12 to 14 feet high. The tree breaks into thin stems close to the ground, and these branch again and again, the leaves being developed umbrella-fashion on the outer branches. The mallee scrub appears like a forest of dried osier, growing so close that it is not always easy to ride through it. Hardly a leaf is visible to the height of one's head; but above, a crown of thick leather-like leaves shuts out the sunlight. The ground below is perfectly bare, and there is no water. Nothing could add to the sterility and the monotony of these mallee scrubs. "Mulga" scrub is a somewhat similar thicket, covering large areas. The tree in this instance is one of the acacias, a genus distributed through all parts of the continent. Some species have rather elegant blossoms, known to the settlers as "wattle." They serve admirably to break the sombre and monotonous aspect of the Australian vegetation. Two species of acacia are remarkable for the delicate and violet-like perfume of their wood—myall and yarran. Proteaceous plants, although not exclusively Australian, are exceedingly characteristic of Australian scenery, and are counted amongst the oldest flowering plants of the world. The order is easily distinguished by the hard, dry, woody texture of the leaves and the dehiscent fruits. They are found in New Zealand and also in New Caledonia, their greatest developments being on the south-west of the Australian continent. Proteaceæ are found also in Tierra del Fuego and Chile. They are also abundant in South Africa, where the order forms the most conspicuous feature of vegetation. The range in species is very limited, no one being common to eastern and western Australia. The chief genera are banksia (*honeysuckle*), and hakea (*needle bush*).

The well-known Moreton Bay pine (*Araucaria Cunninghamii*) is reckoned amongst the giants of the forest. The genus is associated with one long extinct in Europe. Moreton Bay pine is chiefly known by the utility of its wood. Another species, *A. Bidwilli*, or the bunya-bunya, afforded food in its nut-like seeds to the aborigines. A most remarkable form of vegetation in the north-west is the gouty-stemmed tree, one of the Malvaceæ. It is related closely to the famous baobab of tropical Africa. The "grass-tree" (*Xanthorrhœa*), of the uplands and coast regions, is peculiarly Australian in its aspect. It is seen as a clump of wire-like leaves, a few feet in diameter, surrounding a stem, hardly thicker than a walking-stick, rising to the height of ten or twelve feet. This terminates in a long spike thickly studded with white blossoms. The grass-tree gives as distinct a character to an Australian picture as the agave and cactus do to the Mexican landscape. With these might be associated the gigantic lily of Queensland (*Nymphæa gigantea*), the leaves of which float on water, and are quite eighteen inches across. There is also a gigantic lily (*Doryanthes excelsa*) which grows to a height of 15 feet. The "flame tree" is a most conspicuous feature of an Illawarra landscape, the largest racemes of crimson red suggesting the name. The waratah or native tulip, the magnificent flowering head of which, with the kangaroo, is symbolic of the country, is one of the Proteaceæ. The natives were accustomed to suck its tubular flowers for the honey they contained. The "nardoo" seed, on which the aborigines sometimes contrived to exist, is a creeping plant, growing plentifully in swamps and shallow pools, and belongs to the natural order of Marsiliaceæ. The spore-cases remain after the plant is dried up and withered. These are collected by the natives, and are known over most of the continent as nardoo.

No speculation or hypothesis has been propounded to account satisfactorily for the origin of the Australian flora. As a step towards such hypothesis it has been noted that the Antarctic, the South African, and the Australian floras have many types in common. There is also to a limited extent a European element present. One thing is certain, that we have in Australia a flora that is a remnant of a vegetation once widely distributed. Heer has described such Australian genera as Banksia, Eucalyptus, Grevillea, and Hakea from the Miocene of Switzerland. Another point agreed upon is that the Australian flora is one of vast antiquity. We have here genera so far removed from every living genus that many connecting links must have become extinct. The region extending round the south-western extremity of the continent has a peculiarly characteristic assemblage of typical Australian forms, notably a great abundance of the Proteaceæ. This flora, isolated by arid country from the rest of the continent, has evidently derived its plant life from an outside source, probably from lands no longer existing.

FAUNA.

More than a hundred marsupials, or about two-thirds of the known species, are natives of Australia. The kangaroo (*Macropus*), emblematic of the island continent, lives in droves in the open grassy plains of the interior. Several smaller forms of the same general appearance are known as wallabys, and are common everywhere. Other terrestrial marsupials are the wombat (*Phascolomys*), a large clumsy burrowing animal, not unlike a pig, which attains a weight of from 60 to 100 lb; the bandicoot (*Perameles*), a rat-like creature whose depredations annoy the agriculturist; the native cat (*Dasyurus*), noted robber of the poultry yard; the Tasmanian wolf (*Thylacinus*), which preys on large game; and the recently-discovered *Notoryctes*, a small animal which burrows like a mole in the desert of the interior. Arboreal species include the well-known opossums (*Phalanger*); the extraordinary tree-kangaroo of the Queensland tropics; the flying-squirrel, which expands a membrane between the legs and arms, and by its aid makes long sailing jumps from tree to tree; and the native bear (*Phascolarctus*), an animal with no affinities to the bear, and having a long soft fur and no tail. More lowly organized than the foregoing are the two monotremes, the Platypus, and Echidna or native porcupine; the former is famous for seeming "half bird, half beast," and is much sought after for its exquisite fur. The dugong lives in the sheltered inlets of the Queensland coast, and is systematically hunted for its oil by natives and whites. Three kinds of seals occur upon the south coast.

The mammals of Australia are with a few exceptions marsupials; that is, they differ profoundly in structure from all other mammals and are lower in the scale of organization. The marsupials of Australia have been isolated from the rest of the world from a period antedating the appearance of higher mammals in other lands. By this isolation they are spared those contests with stronger mammals which resulted in the extermination of the marsupials of other continents, with the exception of the opossums of America. We notice, however, a wonderful development of "groups," parallel with the development of the higher mammals in other lands:—

Placentals of Europe.	Marsupials of Australia.
1. Rodents.	1. Wombat and allies.
2. Carnivora.	2. Native "cats."
3. Insect-eaters.	3. Bandicoots.
4. Hoofed beasts.	4. Kangaroos.
5. Sloths and ant-eaters.	5. Native "bear" and echidna.
6. Mole.	6. Marsupial mole.

The geographical limits of the marsupials are very interesting. The opossums of America are marsupials, though not showing anomalies as great as kangaroos and bandicoots (in their feet), and myrmecobius (in the number of teeth). Except the opossums, no single living marsupial is known outside the Australian zoological region. The forms of life characteristic of India and the Malay peninsula come down to the island of Bali. Bali is separated from Lombok by a strait not more than 15 miles wide. Yet this narrow belt of water is the boundary line between the Australasian and the Indian regions. The zoological boundary passing through the Bali Strait is called "Wallace's line," after the eminent naturalist who was its discoverer. He showed that not only as regards beasts, but also as regards birds, these regions are thus sharply limited. Australia, he pointed out, has no woodpeckers and no pheasants, which are widely-spread Indian birds. Instead of these it has mould-making turkeys, honey-suckers, cockatoos, and brush-tongued lories, all of which are found nowhere else in the world.

The *Myrmecobius* of Western Australia is a bushy-tailed ant-eater about the size of a squirrel, and from its lineage and structure of more than passing interest. It is, Mivart remarks, a survival of a very ancient state of things indeed. It had ancestors in a flourishing condition during the Secondary epoch. Its congeners even then lived in England, as is proved by the fact that their relics have been found in the Stonesfield oolitic rocks, the deposition of which is separated from that which gave rise to the Paris Tertiary strata by an abyss of past time which we cannot venture to express even in thousands of years.

Australia is rich in snakes, and has more than a hundred different kinds. Most of these are venomous, but all are not equally dreaded. Five rather common species are certainly deadly—the death adder, the brown, the black, the superb, and the tiger snakes. During the colder months these reptiles remain in a torpid state. No certain cure has been or is likely to be discovered for their poison, but in less serious cases strychnine has been used with advantage. In tropical waters a sea snake is found, which, though very poisonous, rarely bites. Among the inoffensive species are counted the graceful green "tree snake," which pursues frogs, birds, and lizards, to the topmost branches of the forest; also, several species of pythons, the commonest of which is known as the carpet snake. These great reptiles may attain a length of 10 feet; they feed on small animals, which they crush to death in their folds. In the estuaries of the Northern Queensland rivers crocodiles abound. Some aged examples reach a length of 25 feet, and such are most dangerous. A small and inoffensive species is found near Port Darwin. Lizards occur in great profusion and variety. A monitor is popularly known as the "goanna," a name derived from iguana, an entirely different animal. The "frilled lizard" is a most remarkable creature. When brought to bay it stands erect on its hind-legs, extends an umbrella-like frill around its neck, and at the same time opens wide its jaws. The horned lizard of Western Australia (*Moloch horridus*) is reputed the ugliest of existing animals, being covered all over with sharp spines, which give it a vicious and repulsive appearance; really, however, it is most inoffensive. Frogs of many kinds are plentiful, the brilliant green frogs being especially conspicuous and noisy.

Two other creatures may be ranked with myrmecobius, as of more than passing interest to the naturalist. The "mud-fish" of Queensland (*Ceratodus Forsteri*) belongs to an ancient order of fishes—the Dipnoi, only a few species of which have survived from past geological periods. The Dipnoi show a distinct transition between fishes and amphibia. For many years only two species were known to science: *Lepidosiren paradoxa* of South America and *Lepidosiren* (*Protopterus*) *annectens* of Africa. Recently, however, the Australian mud-fish has been referred to the Dipnoi,—for it was seen that it was provided with a gill-like breathing apparatus, and also true lungs. The blood circulation is in a sense intermediate between that of frogs and fishes. The heart has one ventricle and two auricles. So far the mud-fish is known only from the Mary and the Burnett rivers. Hardly of less scientific interest is the Port Jackson shark (*Heterodontus*). It is a harmless helmeted ground-shark, living on molluscs, and almost the sole survivor of a genus abundant in the Secondary rocks of Europe. One of its remarkable characteristics is the pavement of crushing teeth with which the mouth is lined. The beautiful *Trigonia* shell, so plentiful in Sydney harbour, is another genus originally believed to be extinct. The first descriptions were published from fossil forms. It was a welcome discovery to find *Trigonia* still surviving in Australian seas. There are only about five species living to-day, and even these are not plentiful. In the Secondary period, however, they must have been extremely abundant; they swarmed in Oolitic seas.

Another link connecting the present fauna of Australia with that of Secondary Europe has recently been discovered. For a considerable time a peculiar group of herrings (*Diplomystus*), characterized by a row of scutes on the back, resembling those found in other types on the opposite aspect of the body, have been known from Cretaceous and early Tertiary rocks, their range including Brazil, Wyoming, and the Isle of Wight. Until recently these herrings were considered to be extinct, but they have now been found alive in certain rivers of New South Wales.

The origin of the fauna and flora of Australia has of late attracted considerable attention. Much accumulated evidence, biological and geological, has pointed to a southern extension of India, an eastern extension of South Africa, and a western extension of Australia into the Indian Ocean. The comparative richness of proteaceous plants in Western Australia and South Africa first suggested a common source for these primitive types. Dr H. O. Forbes drew attention to a certain community amongst birds and other vertebrates, invertebrates, and amongst plants, on all the lands stretching towards the South Pole. A theory was therefore propounded that these known types were all derived from a continent which has been named Antarctica. The supposed continent extended across the South Pole, practically joining Australia and South America. Just as we have evidence of a former mild climate in the Arctic regions, so a similar mild climate has been postulated for Antarctica. Modern naturalists consider that many of the problems of Australia's remarkable fauna and flora can be best explained by the following hypothesis:—The region now covered by the Antarctic ice-cap was in early Tertiary times favoured by a mild climate; here lay an Antarctic continent or archipelago. From an area corresponding to what is now South America there entered a fauna and flora, which, after undergoing modification, passed by way of Tasmania to Australia. These immigrants then developed, with some exceptions, into the present Australian flora and fauna. This theory in the course of a decade has advanced from the position of a disparaged heresy to acceptance by leading thinkers. The discovery as fossil, in South America, of primitive or ancestral forms of marsupials has given it much support. One of these, *Prothylacinus*, is regarded as the forerunner of the marsupial wolf of Tasmania. An interesting link between divergent marsupial families, still living in Ecuador, the *Cænolestes*, is another discovery of recent years. On the Australian side the fact that Tasmania is richest in marsupial types indicates the gate by which they entered. It is not to be supposed that this Antarctic element, to which Professor Tate has applied the name *Euronotian*, entered a desert barren of all life. Previous to its arrival Australia doubtless possessed considerable vegetation and a scanty fauna, chiefly invertebrate. At a comparatively recent date Australia received its third and newest constituent. The islands of Torres Strait have been shown to be the denuded remnant of a former extension of Cape York peninsula in North Queensland. Previous to the existence of the strait, and across its site, there poured into Australia a wealth of Papuan forms. Along the Pacific slope of the Queensland Cordillera these found in soil and climate a congenial home. Among the plants the wild banana, pepper, orange, and mangosteen, rhododendron, epiphytic orchids, and the palm; among mammals the bats and rats; among birds the cassowary and rifle birds; and among reptiles the crocodile and tree snakes, characterize this element. The numerous facts, geological, geographical and biological, which when linked together lend great support to this theory, have been well worked out in Australia by Mr Charles Hedley of the Australian Museum, Sydney.

STATISTICS.[1]

Climate. — The tropic of Capricorn divides Australia into two parts. Of these the northern or intertropical portion contains 1,145,000 square miles, comprising half of Queensland, the Northern Territory of South Australia, and the north-western divisions of West Australia. The whole of New South Wales, Victoria, and South Australia proper, half of Queensland, and more than half of West Australia, comprising 1,801,700 square miles, are without the tropics. In a region so extensive very great varieties of climate are naturally to be expected, but it may be stated as a general law that the climate of Australia is milder than that of corresponding lands in the Northern Hemisphere. During July, which is the coldest month in southern latitudes, one half of Australia has a mean temperature ranging from 45° to 61°, and the other half from 62° to 80°. The following are the areas subject to the various average temperatures during the month referred to:—

Temperature Fahr.	Area in Square Miles.
45°-50°	18,800
50°-55°	596,300
55°-60°	681,800
60°-65°	834,400
65°-70°	515,600
70°-75°	275,900
75°-80°	24,500

The temperature in December ranges from 60° to above 95° Fahr., half of Australia having a mean temperature below 84°. Dividing the land into zones of average summer temperature, the following are the areas which would fall to each:—

Temperature Fahr.	Area in Square Miles.
60°-65°	67,800
65°-70°	63,700
70°-75°	352,300
75°-80°	439,200
80°-85°	733,600
85°-90°	570,600
90°-95°	584,100
95° and over	135,400

Judging from the figures just given, it must be conceded that a considerable area of the continent is not adapted for colonization by European races. The region with a mean summer temperature in excess of 95° Fahr. is the interior of the Northern Territory of South Australia north of the 20th parallel; and the whole of the country, excepting the seaboard, lying between the meridians of 120° and 140°, and north of the 25th parallel, has a mean temperature in excess of 90° Fahr.

Recent observations confirm the earlier opinions as to the dryness of the Australian climate, and it may be taken that nearly 40 per cent. of the area of the continent has not a greater annual rainfall than 10 inches. This dry area is shaped like a flattened oval lying between the 117th and 142nd meridian east and the parallels of 21° and 32° south. Very little of Queensland and New South Wales and no part of Victoria lie within this area. The following table shows the rainfall zones in square miles:—

Rainfall.	Rainfall Areas in Square Miles.
Under 10 inches	1,219,600
10 to 20 ,,	843,100
20 to 30 ,,	399,900
30 to 40 ,,	225,700
40 to 50 ,,	140,300
50 to 60 ,,	47,900
60 to 70 ,,	56,100
Over 70 ,,	14,100
Total	2,946,700

Population. — The Australian people are mainly of British origin, only 5 per cent. of the population of European descent being of non-British race. It is certain that the aborigines are very much less numerous than when the country was first colonized, but their present numbers can be given for only a few of the states. At the census of 1891, 38,879 aborigines were enumerated, of whom 8280 were in New South Wales, 565 in Victoria, 23,789 in South Australia, and 6245 in West Australia. It has been asserted by the Queensland authorities that there are 70,000 aborigines in that state; but this is a crude estimate, and may be far wide of the truth. In South Australia and the Northern Territory a large number are outside the bounds of settlement, and it is probable that they are as numerous there as in Queensland. The census of West Australia included only those aborigines in the employment of the colonists; and as a large part of this, the greatest of the Australian states, is as yet unexplored, it may be presumed that the aborigines enumerated were very far short of the whole number of persons of that race in the state. Taking all things into consideration, the aboriginal population of the continent may be set down at something like 200,000. The Chinese number about 36,000, and are chiefly found in New South Wales and Queensland; South Sea Islanders and other coloured races number probably about 16,000, and are to be found principally in Queensland. On the 1st January 1900 the population of Australia was 3,535,430, but this figure is exclusive of aborigines living outside the boundaries of settlement. The increase of population since 1870 was as follows:—1870, 1,549,706; 1880, 2,130,686; 1890, 3,013,790. The expansion has been due mainly to the natural increase; that is, by reason of excess of births over deaths. Immigration to Australia has not been on a large scale since the first gold discoveries. The distance from Europe and the cost of the passage tend to prevent the flow of population, but added to this there has been lately a disinclination on the part of the Australian Governments, except those of Queensland and West Australia, to encourage immigration and provide for the welfare of the immigrants on their arrival. During the last ten years the inflow of population has not averaged more than four or five thousand a year, and in 1899 there was an actual excess of emigrants to the number of 5189. The natural increase of population is about 14½ per thousand, a ratio very little higher than in Great Britain, where the excess of births over deaths is about 12 per thousand, and far below the average obtaining in these states a few years ago. In 1899 the births numbered 95,964 and the deaths 45,425, showing a ratio per thousand equal to 27·25 and 12·90 respectively. In 1891 the births numbered 105,215 and the deaths 45,187, giving the ratios of 34·42 and 14·78 per thousand respectively. There has been a very great falling-off in the proportion of births to marriages, to such an extent indeed that the rate of Australia, which was formerly very high, has now dropped to the European level. This change has taken place since 1884. On the other hand there has been an improvement in the death-rates. The marriages in 1899 numbered 24,811, which gives a proportion of 7·05 per thousand inhabitants. This ratio is below the normal, and may be expected to be increased to about 7·50 per thousand, which was about the average for the years 1886 to 1890. The decline in the Australian marriage-rate was largely due to the bank failures which occurred in 1893, and from which the states have made a very slow recovery.

Australia contains only four cities whose population exceeds 100,000, and fifteen with over 10,000. The principal cities and towns are Sydney (pop. 489,000), Newcastle,

---

[1] These statistics refer only to the continental states of the Federation, not to Tasmania.

Broken Hill, Parramatta, Goulburn, Maitland, Bathurst, Grafton, Albury, and Orange in New South Wales; Melbourne (pop. 494,000), Ballarat, Bendigo, Geelong, Warrnambool, Castlemaine, and Stawell in Victoria; Brisbane (pop. 120,000), Rockhampton, Maryborough, Townsville, Gympie, Ipswich, and Toowoomba in Queensland; Adelaide (pop. about 162,000, including Port Adelaide) in South Australia; Perth (pop. 44,000) and Fremantle in West Australia.

ABORIGINES.

The aborigines of Australia are a single race throughout the whole continent. They are far removed in character from any other peoples, and have evidently been isolated from the rest of the human race from prehistoric times. Although their physical and mental characters stamp them as one, it is generally accepted now that the race is a blend of two or three different elements, introduced into Australia probably when the continent was still connected by dry land with New Guinea. If the aboriginal races be divided, as they conveniently may, into three classes, class A would be characterized as follows:—Hunters and fishers who dig for tubers, build crude canoes, have implements of rude design, have no fixed abode and no buildings. Class B would comprise hunters of a higher class, having finer-finished weapons, showing skill in carving, dressing neatly, and having habitations. Class C would include a higher grade, namely, those with fixed habitations, some rude method of agriculture, and some form of government. The Australian aborigines undoubtedly belong to the first or lowest class. They are typical hunters, "in this respect unapproached by the Canadian trapper, the South African bushman, or any other people, savage or civilized." Although in physical appearance the natives vary considerably, still they are clearly differentiated from any other race. The colour of the skin ranges from dusky copper to black. Muscle is usually not well developed, the legs in particular being notably destitute of calves. The physique of the aborigines of the central and more arid portions of the continent is not, as might be expected, up to that of the favoured tribes living on the coast or coastal uplands. Except in the arid interior the Australian black-fellow averages 5 feet 6 inches in height, while savages standing 6 feet are not uncommon. There is usually an abundance of hair on the face and breast; but towards the northern portions of the continent it has been noted that the aboriginal has a less luxuriant beard. The hair of the head is raven black and wavy; this is somewhat modified where Papuan influence has been felt, the hair then being quite curly and frizzly. The peculiarities about the aboriginal's head are very marked. The skull is abnormally thick and the cerebral capacity small. The head is long and somewhat narrow, and the forehead recedes in a marked degree. He has usually excellent teeth, and the hands and feet are not strikingly large. The black-fellow's carriage is graceful and erect; he walks with the head well thrown back, and his senses are always on the alert. His powers in tracking, stalking his prey, and hurling his spear are proverbial. His implements, offensive and defensive, have been well described by standard authors, but little or no light has been thrown on the origin of that wonderful weapon, the boomerang. Some writers have taken the trouble to show that the boomerang was in use ages ago in Africa and in India; but if we define the boomerang as an instrument which when projected into the air returns to its thrower, it may be safely said that we have no proof that any other race ever knew of such an implement. The boomerang that returns to the thrower is rarely if ever used for fighting purposes. The stone implements of the aborigines may be said to be crude in the extreme. But any good collection of their implements will show—(1) flakes; (2) knives, in many varieties; (3) spear-heads; (4) chisels; (5) scrapers; (6) needles or awls; (7) hammers; (8) anvils; and (9) grinding stones. Tomahawks showing a high finish are sometimes found, but they were evidently rare. There is nothing specially distinctive about the stone implements to distinguish them from those of other primitive peoples.

Closer study has not improved on previous estimates as to the paradoxical moral code of the aborigines. A wife will be beaten without mercy for unfaithfulness to her husband, but the same wife will have had to submit to the first-night promiscuity, a widespread revel which Roth shows is a regular custom in North-west Central Queensland. A husband claims his wife as his absolute property, but he has no scruple in handing her over for a time to another man. There is no proof that anything like community of women or unlimited promiscuity exists anywhere. It would be wrong, however, to conclude that moral considerations have led up to this state of things. Of sexual morality, in the everyday sense of the word, there is none. Although not invariably cannibals, the aboriginal relishes human flesh. In his treatment of women the aboriginal may be ranked lower than even the Fuegians. Early in life the young girls are subjected to horrible mutilation (introcision), which is in some obscure way associated with quite a different operation, "the terrible rite" or male introcision, to which young men are subjected. The operation may be said to be confined to the tribes of Central and North-central Australia. The Tasmanians knew nothing of the rite, or of circumcision, and they are believed to represent the original stock that spread over the continent, and, being the most isolated, advanced but little.

The following description by Mr W. A. Horn will apply with little modification to the black-fellow over the whole continent:—"The Central Australian aboriginal is the living representative of a stone age, who still fashions his spear-heads and knives from flint or sandstone, and performs the most daring surgical operations with them. His origin and history are lost in the gloomy mists of the past. He has no written records and few oral traditions. In appearance he is a naked, hirsute savage, with a type of features occasionally pronouncedly Jewish. He is by nature light-hearted, merry and prone to laughter, a splendid mimic, supple-jointed, with an unerring hand that works in perfect unison with the eye, which is as keen as that of an eagle. He has never been known to wash. He has no private ownership of land, except as regards that which is not over-carefully concealed about his person. He cultivates nothing, and lives entirely on the spoils of the chase; and although the thermometer frequently ranges from 15° to over 90° F. in twenty-four hours, and his country is by no means devoid of furred game, he makes no use of the skins for clothing, but goes about during the day and sleeps in the open at night perfectly nude. He builds no permanent habitation and usually camps where night or fatigue overtakes him. He can travel from point to point for hundreds of miles through the pathless bush with unerring precision, and track an animal over rocks and stones, where a European eye would be unable to distinguish a mark. He is a keen observer, and knows the habits and changes of form of every variety of animal or vegetable in his country. Religious belief he has none, but is excessively superstitious, living in constant dread of an Evil Spirit which is supposed to lurk around his camp at night. He has no gratitude except that of the anticipatory order, and is as treacherous as Judas. He has no traditions, and yet continues to practise with scrupulous exactness a number of hideous customs and ceremonies which have been handed down from his fathers, and of the origin or reason of which he knows nothing. Ofttimes kind and even affectionate to those of his children who have been permitted to live, he yet practises, without any reason except that his father did so before him, the most cruel and revolting mutilations upon the young men and maidens of his tribe."

Every traveller on the Queensland coast must have noticed that, directly a boat puts off for the shore, smoke signals ascend from point to point as far as the eye can reach. It is now ascertained that information of a varied character can be conveyed over long distances by smoke signals. For the purpose of signalling, the Queensland blacks use a complicated system based on the following signals:—(1) The slender column of light-coloured smoke; (2) a heavy column of smoke; (3) a slender column of black smoke; (4) interrupted or intermittent columns of smoke; (5) groups or columns of smoke columns. Much attention has been given to the instrument known as "bullroarer," as being one of the few instruments used by the Australian aboriginal and far-distant primitive peoples. A flat piece of wood is attached at one end to a string and rapidly whirled in sling fashion. Vibrations are set up resulting in a roar, which has an extraordinary effect upon the hearer. Women and children are never allowed to see the instrument; and when in the absolute stillness of the forest the buzzing of the roar rises and falls, people unable to account for such weird sounds are awed beyond measure. Mr A. W. Howitt, writing on the subject, remarks: "The universality of its use, and under the same conditions, in world-wide localities, is one of the most puzzling questions in this branch of anthropology, and can only, as it seems to me, point to its extreme antiquity."

The most cursory observer of the aboriginal will notice that he makes no visible acknowledgment of a Supreme Being. He has no altar and no form of sacrifice. The fear of any future punishment or the hope of any future reward is neither a deterrent nor an incentive. If he has a religion, it is something completely apart from morals. There is no evidence to show that a black-fellow is guided or influenced in any action by the knowledge of a Supreme Power to whom he is responsible.

The route by which the blacks arrived in Australia has not yet been placed beyond question. If the Tasmanians be accepted as the nearest approach to the primitive type, then we have a race that had neither a boomerang nor a shield. Their whole belongings consisted of stone tomahawks and a few crude spears. If this represents the stage to which primitive man had reached when the blacks first peopled Australia, then their coming must be placed far back in the early history of mankind. That they have been isolated for long ages may be taken for granted. They have derived little or nothing from the present races to the north of Torres Strait. Certainly the blacks of North Australia seem somewhat in advance of the aborigines generally. But no clear connexion exists either in language, or manners, or customs with Malays or Papuans. The sunny and playful disposition of the aboriginal points to Papuan rather than Malay blood, but the probability is that the natives were in possession long before the present distribution of Papuan and Malay. The blacks on parts of the north coast use an outrigger to their canoes—an idea evidently introduced from beyond Torres Strait. The bow and arrow are not known among the aborigines of Australia. The question arises as to whether they were ever acquainted with their use. Had they ever known such weapons, it is hardly likely that the knowledge of them could ever have been lost. Depending, as the Australian black-fellow did, on the chase, nothing could be better fitted for his wants. The absence of these implements points conclusively to the fact that the ancestors of these people reached Australia before the bow and arrow became what they are now, implements in use by almost all races. It is not necessary that the first-comers should have been skilful navigators. Possibly there was land connexion between Australia and New Guinea in post-Tertiary times, by means of which the aborigines made their way.

The study of the languages of the various tribes has so far yielded nothing of exceptional importance. As an instance of how a spoken tongue may vary in a short time the following is of interest:—In 1893 a wild tribe of natives was discovered in the Wentworth district of New South Wales. This tribe originated through a black-fellow hiding in some little-known country with a few gins for some thirty years. In that time the tribe had grown to thirty—men, women, and children. The country they were concealed in is known as mallee scrub, the most wretched kind of land known in the state. The tribe lived as only black-fellows can on kangaroo, wild cat, and ant eggs. They used water bags made from the skins of kangaroo legs. They produced fire in the old way by rubbing two sticks together, and their only weapons were spears, which were merely stems of mallee, roughly pointed and barbed. The remarkable fact is that the station blacks had considerable difficulty in making the wild tribe understand them, although thirty years before they must have spoken the same language.

For purposes of comparison the aboriginal character, habits, and customs may be summed up as follows:—

Moral, Mental, and Social.—No moral code. A clear idea of individual ownership in property. A wife is held as property. No idea of a Supreme Being. Unable to grasp abstract ideas. No idols, no altar, and no form of sacrifice. No form of prayer or supplication. Not in any way guided in their actions by the hope of future reward or future punishment. No written language. Build no houses. No pottery. No weaving. No idea of moral justice. No art, save the making of some plaited bags. Very fearful of unseen dangers and in constant dread of witchcraft. No ownership in land, but the tribes have a well-understood limit to their hunting-grounds. Reached only to the "binary stage" in counting. Have a gesture speech, more or less perfected in various tribes, and often a complete code of smoke signals. In all that concerns hunting and the chase, their senses are far keener than those of civilized man.

Customs, &c.—Circumcision practised over most of the continent. The rite of male and female introcision practised in a horrible manner by many tribes. Some tribes force the young women to submit to promiscuity after the operation, but this is a thing quite apart from "communal marriage" or general promiscuity. Mutual avoidance of mother-in-law and son-in-law. A complicated marriage relationship. No marriage ceremony. A wife is procured by purchase, as a gift from her parents, or occasionally by forcible abduction. Polygamy is recognized. Infanticide practised. Cannibalism common. Typical hunters, but do not use the bow and arrow. Most tribes have a chief or head man, but his office is not hereditary, neither is a chief elected.

Implements, &c.—Stone chisels, hammers, and tomahawks. Barbed spears. The boomerang. A throwing stick for spears. Various clubs, and fighting boomerangs not made to return to the thrower. Make crude canoes and plait twine nets, bags, and armlets.

It is right to add that the black-fellow, when unspoiled by aggression and bad treatment, is docile, capable of kindness, and even of great affection. But even here he is inconstant. The early explorers found them an inoffensive people; and even at the date of writing the tribes who practise the dreadful mutilations referred to are seldom hostile, and, when their womenfolk are not taken from them, they are disposed to be friendly.

Religion.—There is no state church in Australia, nor is the teaching of religion in any way subsidized by the state. The Church of England claims as adherents 39 per cent. of the population, and the Roman Catholic Church 22 per cent.; next in numerical strength are the Wesleyans and other Methodists, numbering 12 per cent., the various branches of the Presbyterians 11 per cent., Congregationalists 2 per cent., and Baptists 2 per cent. At the beginning of the year 1900 it was estimated that there were in Australia 1,374,000 adherents of the Church of England, 783,000 Roman Catholics, 385,000 Presbyterians, 79,000 Congregationalists, and 81,000 Baptists.

Instruction.—Education is very widely distributed, and in every state it is compulsory for children of school ages to attend school. The statutory ages differ in the various states: in New South Wales and West Australia it is from 6 to 13 years, in Victoria 6 to 12 years, in Queensland 6 to 11 years, and in South Australia 7 to 12 years inclusive. Religious instruction is not imparted by the state-paid teachers in any state, though in certain states persons, duly authorized by the religious organizations, are allowed to give religious instruction to children of their own denomination where the parents' consent has been obtained. According to the returns for 1899 there were 6357 state schools, with 13,462 teachers and 585,556 pupils, and the average attendance of scholars was 411,331. Besides state schools there were 2454 private schools, with 7778 teachers and 140,285 scholars, the average number of scholars in attendance being 109,389. The census of 1891 showed that about 76 per cent. of the whole population and more than 88 per cent. of the population over five years of age could read and write. There was, therefore, a residue of 12 per cent. of "illiterates," most of whom were not born in Australia. The marriage registers furnish another test of education. In 1899 only thirteen persons in every thousand married were unable to sign their names, thus proving that the number of illiterate adults of Australian birth is very small.

Public Finance.—The public revenues and expenditures of the various Governments for the year ending June 1900 were:—

	Revenue.	Expenditure.
New South Wales	£9,973,736	£9,811,402
Victoria	7,450,676	7,318,945
Queensland	4,588,207	4,540,418
South Australia	2,853,329	2,936,619
West Australia	2,875,396	2,615,675

The chief sources of revenue are customs taxation, railways, postal receipts, &c., and public lands. There are direct taxes on land and incomes in New South Wales, Victoria, and South Australia. The sums obtained during 1900 from the various sources named were:—

Customs and Excise	£7,180,907
Other Taxation	2,320,076
Railways, &c.	10,440,347
Postal and Telegraphs	2,148,335
Public Lands	3,430,641
Other sources	2,221,038

The expenditure may be grouped as follows:—

Railways and Working Expenses	£6,397,686
Postal and Telegraphs	2,095,810
Public Instruction	1,760,207
Interest and Charges on Debts	7,274,923
All other services	9,694,433

The public debt of the states on 30th June 1900 was £186,813,712, thus distributed:—

New South Wales	£65,332,993
Victoria	49,324,885
Queensland	34,349,414
South Australia	26,131,780
West Australia	11,674,640

About 80 per cent. of the whole public debt has been incurred for the purpose of constructing public works yielding a direct revenue; but the proportion varies in each state, and the details of the debt will be found under the head of each particular state. The area of Australia is 2,946,691 square miles, or 1,885,882,240 acres; of this area the states have sold or otherwise parted with nearly 107,000,000 acres, and have under lease 779,000,000 acres. The bulk of the best land has been sold, the area neither leased nor sold, which amounts to about 1,000,000,000 acres, being chiefly in West and South Australia, and for the most part outside the region of regular rainfall.

Defence.—Practically there is no standing army in Australia, as the total number of paid soldiers is only 1571. This small permanent force is supported by a partially-paid force of 14,066, and an unpaid or strictly volunteer force of 6063 men. There are in each state, besides the land forces, small corps of naval volunteers capable of being employed as light artillery land forces or upon the local war vessels. Although the regular military force of the states is very small, Australasia (including New Zealand) was able to despatch 8300 troops for service in South Africa, and of these 6310 belonged to Australia proper. The naval defence of Australia is entrusted to the Imperial Navy, and Sydney, the headquarters of the fleet, ranks as a first-class station.

Fisheries.—The only deep-sea fisheries now carried on to any extent in Australia are the pearl fisheries in Queensland and West Australia. At one time whaling was an important industry on the coasts of New South Wales and Tasmania, and afterwards on the Western Australian coasts. The industry gravitated to New Zealand, and finally died out, chiefly through the wasteful practice of killing the calves to secure the capture of the mothers. Of late years whaling has again attracted attention, and a small number of vessels prosecute the industry during the season. The diving for pearl shell is actively carried on in Torres Strait, and has become an important industry, giving employment to nearly 2000 men, and the take in 1899 was 1200 tons of shell, valued at £130,105. Besides shell some bêche-de-mer and tortoise-shell is obtained. The pearl shell industry of West Australia is chiefly carried on along the north-west coast and in Shark Bay, but the production now shows a large falling-off owing to the exhaustion of the inshore banks. The value of pearls and pearl shell raised in 1899 amounted to £96,000, the banks at Shark Bay yielding only £3824, compared with £16,043 in 1890.

Timber Industry.—The timber industry is prosecuted on a large scale in West Australia and New South Wales, especially in the first-named state, where very extensive forests of splendid hardwoods exist. In 1899 the value of timber exported was—from West Australia £553,198, and New South Wales £102,218, the combined exports of the other three states only reaching £17,000. These figures do not indicate the whole value of the industry, especially in New South Wales, where a larger quantity is consumed locally than is exported.

Grazing and Agriculture.—The continent is essentially a pastoral one, and in 1899 depastured 72,625,000 sheep, 9,678,000 cattle, 1,639,000 horses, besides large numbers of swine; the figures show a great falling-off from previous years, for in 1891 there were 104,800,000 sheep and 10,860,000 cattle depastured. The butter industry is making great progress, and there were, in 1899, 1,102,000 head of dairy cattle, and the butter made was little short of 100,680,000 ℔. Next to the pastoral industry agriculture is the principal source of Australian wealth. In 1900 the area devoted to tillage was 8,441,000 acres, namely, wheat 5,550,000 acres; maize, 336,000 acres; oats, 325,000 acres; other grains, 121,000 acres; hay, 1,454,000 acres; potatoes, 112,000 acres; sugar-cane, 133,000 acres; vines, 61,000 acres; and other crops, 349,000 acres. The chief wheat lands are in Victoria, South Australia, and New South Wales; the yield averages about 9 bushels to the acre, and is lowest in South Australia. Maize and sugar-cane are grown in New South Wales and Queensland. The vine is cultivated in all the states, but chiefly in South Australia, Victoria, and New South Wales. Australia produces abundant quantities and nearly all varieties of fruits; but the kinds exported are chiefly oranges, pineapples, bananas, and apples. Tobacco thrives well in New South Wales and Victoria, but kinds suitable for exportation are not largely grown. Compared with the principal countries of the world, Australia does not take a high position in regard to the gross value of the produce of its tillage, but in value per inhabitant it compares fairly well; indeed, some of the states show averages which surpass those of many of the leading agricultural countries. For 1900 the total value of agricultural produce estimated at the place of production was £17,000,000 sterling, or about £4, 16s. 7d. per inhabitant.

Mineral Production.—Australia is one of the great gold producers of the world, and its yield in 1899 was about £14,334,000 sterling, and the total value of its mineral production was approximately £19,663,000. Gold is found throughout Australia, and the present prosperity of the states is largely due to the discoveries of this metal, the development of other industries being, in a country of varied resources, a natural sequence to the acquisition of mineral treasure. From the date of its first discovery, up to the close of 1899, gold to the value of £368,160,000 sterling had been obtained in Australia. Victoria, in a period of forty-eight years, contributed about £254,000,000 to this total, and is still a large producer, its annual yield being about 736,000 oz., 29,000 men being engaged in the search for the precious metal. Queensland's annual output is 705,000 oz.; the number of men engaged in gold-mining is 10,000. In New South Wales the greatest production was in 1852, soon after the first discovery of the precious metal, when the output was valued at £2,660,946; the production in 1899 was about 496,000 oz., valued at £1,752,000. Until recently West Australia was considered to be destitute of mineral deposits of any value, but it is now known that a rich belt of mineral country extends from north to south. The first important discovery was made in 1882, when gold was found in the Kimberley district; but it was not until a few years later that this rich and extensive area was developed. In 1887 gold was found in Yilgarn, about 200 miles east of Perth. This was the first of the many rich discoveries in the same district which have made West Australia the chief gold-producer of the Australian group. At the present time there are eighteen goldfields in the state, and it is estimated that over 20,000 miners are actively engaged in the search for gold. In 1899 the production amounted to 1,644,000 oz., as compared with 30,310 oz. in 1891. Of all the Australian states South Australia has produced the smallest quantity of gold, the total output from the commencement of mining operations being valued at little more than £2,213,000 sterling. The following table gives the value of gold raised from the commencement of mining to the close of the year 1899:—

State.	Value Produced
New South Wales	£47,546,000
Victoria	254,157,000
Queensland	47,338,000
South Australia	2,213,000
West Australia	16,906,000

The production of gold, which had been declining steadily for many years, reached the lowest point in 1886. Since then there has been a marked revival. The production of gold in each state in 1899 is given below:—

State.	Weight. Oz.	Value of Gold.
New South Wales	496,196	£1,751,815
Victoria	854,500	3,418,000
Queensland	946,894	2,838,119
South Australia	23,123	79,041
West Australia	1,643,877	6,246,733

The following shows the number of miners at work:—

State.	Miners Employed.
New South Wales	19,300
Victoria	30,100
Queensland	9,800
South Australia	2,000
West Australia	21,000

The greatest development of quartz reefing is found in Victoria, some of the mines being a great depth. There are seven mines in the Bendigo district over 3000 feet deep, and fourteen over 2500 feet deep. In Lansell's 180 Mine a depth of 3352 feet has been reached, and in Lazarus Mine 3424 feet. In the Ballarat district a depth of 2520 feet has been reached in the South Star Mine.

Silver has been discovered in all the states, either alone or in the form of sulphides, antimonial and arsenical ores, chloride, bromide, iodide, and chloro-bromide of silver, and argentiferous lead ores, the largest deposits of the metal being found in the last-mentioned form. The leading silver mines are in New South Wales, the returns from the other states being comparatively insignificant. The fields of New South Wales have proved to be of immense value, the yield of silver during 1899 being £2,070,400, and the total output to the end of the year named £28,000,000. The Broken Hill field, which was discovered in 1883, extends over 2500 square miles of country, and has developed into one of the principal mining centres of the world. It is situated beyond the river Darling, and close to the boundary between New South Wales and South Australia. The lodes occur in Silurian metamorphic micaceous schists, intruded by granite, porphyry, and diorite, and traversed by numerous quartz reefs, some of which are gold-bearing. The Broken Hill lode is the largest yet discovered. It varies in width from 10 feet to 200 feet, and may be traced for several miles. Although indications of silver abound in all the other states, no fields of great importance have yet been discovered. Up to the end of 1899 Australia has produced silver to the value of £29,559,000, of which nearly £28,000,000 was obtained from the fields of New South Wales.

Copper is known to exist in all the states, and has been mined extensively in South Australia, and on a much smaller scale in New South Wales and Queensland. The low quotations which have ruled for a number of years have had a depressing effect upon the industry, and many mines once profitably worked have now been closed. The discovery of copper had a marked effect on the fortunes of South Australia at a time when the young colony was surrounded by difficulties. The first important mine, the Kapunda, was opened up in 1842. It is estimated that at one time 2000 tons were produced annually, but the mine was closed in 1879. In 1845 the celebrated Burra Burra Mine was discovered. This mine proved to be very rich, and paid £800,000 in dividends to the original owners. For a number of years, however, the mine has been suffered to remain untouched, as the deposits originally worked were found to be depleted. For many years the average output was from 10,000 to 13,000 tons of ore, yielding from 22 to 23 per cent. of copper. For the period of thirty years during which the mine was worked the production of ore amounted to 234,648 tons, equal to 51,622 tons of copper, valued at £4,749,924. The Wallaroo and Moonta mines, discovered in 1860 and 1861, proved to be even more valuable than the Burra Burra, the Moonta mines employing at one time upwards of 1600 hands. The dividends paid by these mines amounted to about £1,750,000 sterling. The satisfactory price obtained during recent years has enabled renewed attention to be paid to copper mining in South Australia, and the production of the metal in 1899 was valued at £406,000. The copper mining industry in New South Wales reached its highest point in 1883, when the production was valued at £472,982. The principal deposits of copper are found in the central part of the state between the Macquarie, Darling, and Bogan rivers. Deposits have also been found in the New England and Southern districts, as well as at Broken Hill, showing that the mineral is widely distributed throughout the state. The more important mines are those of Cobar, where the Great Cobar Mine produced, in 1899, 3794 tons of refined copper, valued at £265,580. In Northern Queensland copper is found throughout the Cloncurry district, in the upper basin of the Star river, and the Herberton district. The returns from the copper fields in the state are at present small, owing to the lack of suitable fuel for smelting purposes, which renders the economic treatment of the ore difficult; the development of the mines is also greatly retarded by the want of easy and cheaper communication with the coast. In West Australia copper deposits have been worked for some years. Very rich lodes of the metal have been found in the Northampton, Murchison, and Champion Bay districts, and also in the country to the south of these districts on the Irwin river. As in the other copper-producing states, there has been a revival of the industry in West Australia, the production in 1899 being valued at £36,000. The total value of copper produced in Australia up to the end of 1899 was £29,402,000 sterling, £21,936,000 having been obtained in South Australia, £5,019,000 in New South Wales, and over £2,032,000 in Queensland.

Tin was known to exist in Australia from the first years of colonization. The wealth of Queensland and the Northern Territory of South Australia in this mineral, according to the reports of Dr Jack, late Government geologist of the former state, and the late Rev. J. E. Tenison-Woods, appears to be very great. The most important tin mines in Queensland are in the Herberton district, south-west of Cairns; at Cooktown, on the Annan and Bloomfield rivers; and at Stanthorpe, on the border of New South Wales. Herberton and Stanthorpe have produced more than three-fourths of the total production of the state. During the past few years the production has greatly decreased in consequence of the low price of the metal, but in 1899 a stimulus was given to the industry, and the production was valued at £77,000. In New South Wales lode tin occurs principally in the granite and stream tin under the basaltic country in the extreme north of the state, at Tenterfield, Emmaville, Tingha, and in other districts of New England. The metal has also been discovered in the Barrier Ranges, and many other places. The value of the output in 1899 was set down at £90,000. The yield of tin in Victoria is very small, and until lately no fields of importance have been discovered; but towards the latter end of 1890 extensive deposits were reported to exist in the Gippsland district—at Omeo and Tarwin. In South Australia tin mining is unimportant. In West Australia the production from the tin fields at Greenbushes was valued in 1899 at £25,000. The value of tin produced in Australia is about £100,000 per annum, and the total production to the end of 1899 was valued at £11,743,000, of which £6,383,000 was obtained in New South Wales and £4,526,000 in Queensland.

Iron is distributed throughout Australia, but for want of capital for developing the fields this industry has not progressed. In New South Wales there are, together with coal and limestone in unlimited supply, important deposits of rich iron ores suitable for smelting purposes; and for the manufacture of steel of certain descriptions abundance of manganese, chrome, and tungsten ores are available. The most extensive fields are in the Mittagong, Wallerawang, and Rylstone districts, which are roughly estimated to contain in the aggregate 12,944,000 tons of ore, containing 5,853,000 tons of metallic iron. Magnetite, or magnetic iron, the richest of all iron ores, is found in abundance near Wallerawang in New South Wales. The proximity of coal-beds now being worked should accelerate the development of the iron deposits, which, on an average, contain 41 per cent. of metal. Magnetite occurs in great abundance in West Australia, together with hæmatite, which would be of enormous value if cheap labour were available. Goethite, limonite, and hæmatite are found in New South Wales, at the junction of the Hawkesbury sandstone formation and the Wianamatta shale, near Nattai, and are enhanced in their value by their proximity to coal-beds. Near Lithgow extensive deposits of limonite, or clay-band ore, are interbedded with coal. Some samples of ore, coal, and limestone, obtained in the Mittagong district, with pig-iron and castings manufactured therefrom, were exhibited at the Mining Exhibition in London and obtained a first award.

Antimony is widely diffused throughout Australia, and is sometimes found associated with gold. In New South Wales the principal centre of this industry is Hillgrove, near Armidale, where the Eleanore Mine, one of the richest in the state, is situated. The ore is also worked for gold. In Victoria the production of antimony gave employment in 1890 to 238 miners, but, owing to the low price of the metal, production has almost ceased. In Queensland the fields were all showing development in 1891, when the output exhibited a very large increase compared with that of former years; but, as in the case of Victoria, the production of the metal seems to have ceased. Good lodes of stibnite (sulphide of antimony) have been found near Roebourne, in West Australia, but no attempt has yet been made to work them.

Bismuth is known to exist in all the Australian states, but up to the present time it has been mined for only in three states, viz., New South Wales, Queensland, and South Australia. It is usually found in association with tin and other minerals. The principal mine in New South Wales is situated at Kingsgate, in the New England district, where the mineral is generally associated with molybdenum and gold.

Manganese probably exists in all the states, deposits having been found in New South Wales, Victoria, Queensland, and West Australia, the richest specimens being found in New South Wales. Little, however, has been done to utilize the deposits, the demands of the colonial markets being extremely limited. The ore generally occurs in the form of oxides, manganite, and pyrolusite, and contains a high percentage of sesquioxide of manganese.

Platinum and the allied compound metal Iridosmine have been found in New South Wales, but so far in inconsiderable quantities. Iridosmine occurs commonly with gold or tin in alluvial drifts.

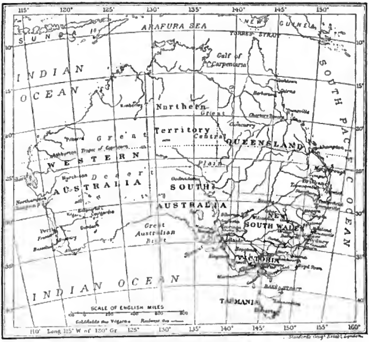
The noble metal Tellurium has been discovered in New South Wales at Bingara and other parts of the northern districts, as well as at Tarana, on the western line, though at present in such minute quantities as would not repay the cost of working. At many of the mines at Kalgoorlie, West Australia, large quantities of ores of telluride of gold have been found in the lode formations.

Lead is found in all the Australian states, but is worked only when associated with silver. In West Australia the lead occurs in the form of sulphides and carbonates of great richness, but the quantity of silver mixed with it is very small. The lodes are most frequently of great size, containing huge masses of galena, and so little gangue that the ore can very easily be dressed to 83 or 84 per cent. The association of this metal with silver in the Broken Hill mines of New South Wales adds very greatly to the value of the product. Up to the end of 1899 the quantity of lead in the ores raised is estimated to have been 523,000 tons.

Mercury is found in New South Wales and Queensland. In New South Wales, in the form of cinnabar, it has been discovered on the Cudgegong river, near Rylstone, and it also occurs at Bingara, Solferino, Yulgilbar, and Cooma. In the last-named place the assays of ore yielded 22 per cent. of mercury.

Titanium, of the varieties known as octahedrite and brookite, is found in alluvial deposits in New South Wales, in conjunction with diamonds.

Wolfram (tungstate of iron and manganese) occurs in some of the states, notably in New South Wales, Victoria, and Queensland. Scheelite, another variety of tungsten, is also found in Queensland. Molybdenum, in the form of molybdenite (sulphide of molybdenum), is found in New South Wales and Victoria, associated in the former state with tin and bismuth in quartz reefs.



Sketch Map of the Mining Fields of Australia.

Zinc ores, in the several varieties of carbonates, silicates, oxide, sulphide, and sulphate of zinc, have been found in several of the Australian states, but have attracted little attention.

Nickel, so abundant in the island of New Caledonia, has up to the present been found in none of the Australian states except Queensland. Few attempts, however, have been made to prospect systematically for this valuable mineral.

Cobalt occurs in New South Wales and Victoria, and efforts have been made in the former state to treat the ore, the metal having a high commercial value; but the market is small, and no attempt has yet been made to produce it on any large scale. The manganese ores of the Bathurst district of New South Wales often contain a small percentage of cobalt, sufficient, indeed, to warrant further attempts to work them. In New South Wales chromium is found in the northern portion of the state, in the Clarence and Tamworth districts, and also near Gundagai. It is usually associated with serpentine. In the Gundagai district the industry was rapidly becoming a valuable one, but the low price of chrome has greatly restricted the output. In 1899 the production was valued at £17,000.

Arsenic, in its well-known and beautiful forms, orpiment and realgar, is found in New South Wales and Victoria. It usually occurs in association with other minerals in veins.

The Australian states have been bountifully supplied with mineral fuel. Five distinct varieties of black coal, of well-characterized types, may be distinguished, and these, with the two extremes of brown coal or lignite and anthracite, form a perfectly continuous series. Brown coal, or lignite, occurs principally in Victoria. Attempts have frequently been made to use the mineral for ordinary fuel purposes, but its inferior quality has prevented its general use. Black coal forms one of the principal resources of New South Wales; and in the other states the deposits of this valuable mineral are being rapidly developed. Coal of a very fair description was discovered in the basin of the Irwin river, in West Australia, as far back as the year 1846. It has been ascertained from recent explorations that the area of carboniferous formation in that state extends from the Irwin northwards to the Gascoyne river, about 300 miles, and probably all the way to the Kimberley district. The most important discovery of coal in the state, so far, is that made in the bed of the Collie river, near Bunbury, to the south of Perth. The coal has been treated and found to be of good quality, and there are grounds for supposing that there are 250,000,000 tons in the field. Dr Jack, late Government geologist of Queensland, considers the extent of the coal-fields of that state to be practically unlimited, and is of opinion that the Carboniferous formations extend to a considerable distance under the Great Western Plains. It is roughly estimated that the Coal Measures at present practically explored extend over an area of about 24,000 square miles. Coal-mining is an established industry in Queensland, and is progressing satisfactorily. The mines, however, are situated too far from the coast to permit of serious competition with Newcastle in an export trade, and the output is practically restricted to supplying local requirements. New South Wales still exports coal to Queensland. The production of the state is about 400,000 tons a year, three-fourths of which is obtained in the Ipswich district. The coal-fields of New South Wales are situated in three distinct regions—the northern, southern, and western districts. The first of these comprises chiefly the mines of the Hunter river districts; the second includes the Illawarra district, and, generally, the coastal regions to the south of Sydney, together with Berrima, on the table-land; and the third consists of the mountainous regions on the Great Western Railway, and extends as far as Dubbo. The total area of the Carboniferous strata of New South Wales is estimated at 23,950 square miles. The seams vary in thickness. One of the richest has been found at Greta in the Hunter river district; it contains an average thickness of 41 feet of clean coal, and the quantity underlying each acre of ground has been computed to be 63,700 tons. The coal mines in New South Wales give employment to 10,340 persons, of whom 8220 are employed underground and 2120 above ground, and the annual production is about 4,700,000 tons. Black coal has been discovered in Victoria, and about 250,000 tons are now being raised. The principal collieries in the state are the Outtrim Howitt, the Coal Creek Proprietary, and the Jumbunna. In South Australia, at Leigh's Creek, north of Port Augusta, coal-beds have been discovered. The quantity of coal extracted annually in Australia has now reached 5,250,000 tons, the estimated production of each state up to the end of 1899 being as follows:—

	Tons.
New South Wales	86,000,000
Victoria	1,500,000
Queensland	5,700,000

This industry gave direct employment in and about the mines to the following numbers of persons in the several states:—

	Miners.
New South Wales	10,340
Victoria	900
Queensland	1,100

Kerosene shale (torbanite) is found in several parts of New South Wales. It is a species of cannel coal, somewhat similar to the Boghead mineral of Scotland, but yielding a much larger percentage of volatile hydro-carbon than the Scottish mineral. The richest quality yields about 100 to 130 gallons of crude oil per ton, or 17,000 to 18,000 cubic feet of gas, with an illuminating power of 35 to 40 sperm candles, when gas only is extracted from the shale. From the year 1865, when the mines were first opened, to the end of 1899, the quantity of kerosene shale raised has amounted to 996,000 tons, valued at £1,908,000.

Large deposits of alum occur close to the village of Bulladelah, 30 miles from Port Stephens, New South Wales. It is said to yield well, and a quantity of the manufactured alum is sent to Sydney for local consumption. Marble is found in many parts of New South Wales and South Australia. Kaolin, fire-clays, and brick-clays are common to all the states. Except in the vicinity of cities and townships, however, little use has been made of the abundant deposits of clay. Kaolin, or porcelain clay, although capable of application to commercial purposes, has not as yet been utilized to any extent, although found in several places in New South Wales and in West Australia.

Asbestos has been found in New South Wales in the Gundagai, Bathurst, and Broken Hill districts—in the last-mentioned district in considerable quantities. Several specimens of very fair quality have also been met with in West Australia.

Many descriptions of gems and gem stones have been discovered in various parts of the Australian states, but systematic search has been made principally for the diamond and the noble opal. Diamonds are found in all the states; but only in New South Wales have any attempts been made to work the diamond drifts. The best of the New South Wales diamonds are harder and much whiter than the South African diamonds, and are classified as on a par with the best Brazilian gems, but no large specimens have yet been found. The finest opal known is obtained in the Upper Cretaceous formation at White Cliffs, near Wilcannia, New South Wales, and at these mines about 700 men find constant employment. Other precious stones, including the sapphire, emerald, oriental emerald, ruby, opal, amethyst, garnet, chrysolite, topaz, cairngorm, onyx, zircon, &c., have been found in the gold and tin-bearing drifts and river gravels in numerous localities throughout the states. The sapphire is found in all the states, principally in the neighbourhood of Beechworth, Victoria. The oriental topaz has been found in New South Wales. Oriental amethysts also have been found in that state, and the ruby has been found in Queensland, as well as in New South Wales. Turquoises have been found near Wangaratta, in Victoria, and mining operations are being carried on in that state. Chrysoberyls have been found in New South Wales; spinel rubies in New South Wales and Victoria; and white topaz in all the states. Chalcedony, carnelian, onyx, and cat's eyes are found in New South Wales; and it is probable that they are also to be met with in the other states, particularly in Queensland. Zircon, tourmaline, garnet, and other precious stones of little commercial value are found throughout Australia.

Commerce.—The shipping trade has expanded very greatly since 1871. In that year the tonnage entered in all the ports of Australia was only 1,679,700 tons; in 1899 it was upwards of 9,998,000 tons. These figures must be taken with qualification, as many of the steamers trading between Europe and Australia call at the principal ports of West Australia, South Australia, Victoria, and New South Wales, and are set down in the returns as entered at all these ports, so that the total tonnage is exaggerated; but when every allowance is made on this score, it will be found that Australia required nearly six times as much shipping in 1899 to carry its trade as it did in 1870. The value of goods imported into the various states in 1899 was £61,801,076; in 1891, £63,505,225; in 1881, £44,094,538; and in 1871, £26,195,760; and the exports during the same period were—1899, £74,488,792; 1891, £61,698,032; 1881, £41,111,798; 1871, £32,360,762. The imports in 1899 represent £17, 11s. 0d. and the exports £21, 3s. 1d. per inhabitant. These figures, however, refer to the gross trade; to arrive at the trade with countries outside Australia a considerable reduction will have to be made, as the value of re-exports in 1899 was approximately £18,636,000, equal to £5, 5s. 10d. per inhabitant; in that year the net imports amounted to £12, 5s. 2d. per inhabitant, and the net exports to £15, 17s. 3d. The bulk of the Australian trade is in British hands, about 35 per cent. of the imports are from Great Britain and about the same proportion of the exports are sent to that country. Australia has long been a favourite place for British investments, and under normal conditions the exports should exceed the imports to the extent of about £10,000,000 or £11,000,000 sterling, which is the amount of income derived from British investments in Australia; but as the state Governments are constantly adding something to their indebtedness and capital is still being sent to Australia for investment, the excess of exports rarely equals the amount named. The principal items of export are wool, skins, tallow, frozen mutton, chilled beef, preserved meats, butter, and other articles of pastoral produce—timber, wheat, flour, and fruits; gold, silver, lead, copper, tin, and other metals. The weight of wool exported was 458,783,000 lb, which is less by 100,000,000 lb than the export in some previous years, the falling-off being due to the effects of the dry seasons which have prevailed throughout Australia for nearly five years.

Railways.—Almost the whole of the railway lines in Australia are the property of the state Governments, and have been constructed and equipped wholly by borrowed capital. There were on the 30th June 1900, 12,448 miles open for traffic, upon which £118,483,048 had been expended. The railways are of different gauges, the standard narrow gauge of 4 feet 8½ inches prevailing only in New South Wales; in Victoria the gauge is 5 feet 3 inches; in South Australia 5 feet 3 inches and 3 feet 6 inches, and in the other states 3 feet 6 inches. Taking the year 1900, the gross earnings amounted to £10,094,431, the working expenses, exclusive of interest, £6,164,402, and the net earnings £3,930,029; the latter figure represents 3·3 per cent. upon the capital expended upon construction and equipment. In two of the states, New South Wales and South Australia proper, the railways yield more than the interest paid by the Government on the money borrowed for their construction; in Victoria the return is equal to 2·8 per cent., in Queensland 2·7, New South Wales 3·6, West Australia 5·8, and South Australia proper 3·9 per cent., but in the Northern Territory of the latter colony the working expenses have exceeded the gross earnings ever since the railways were constructed. The earnings per train mile vary greatly; but for all the lines the average is six shillings, and the working expenses about three shillings and sixpence, making the net earnings two shillings and sixpence per train mile. The ratio of receipts from coaching traffic to total receipts is about 40 per cent., which is somewhat less than in the United Kingdom; but the proportion varies greatly amongst the states themselves, the more densely-populated states approaching most nearly to the British standard. The tonnage of goods carried amounts to about 13,091,000 tons, or over 3·7 tons per inhabitant, which must be considered fairly large, especially as no great proportion of the tonnage consists of minerals on which there is usually a low freightage. Excluding coal lines and other lines not open to general traffic, the length of railways in private hands is only 382 miles, or about 3 per cent. of the total mileage open. Of this length, 277 miles are in West Australia. The divergence of policy of that state from that pursued by the other states was caused by the inability of the Government to construct lines, when the extension of the railway system was urgently needed in the interests of settlement. Private enterprise was therefore encouraged by liberal grants of land to undertake the work of construction; but the changed conditions of the state have now altered the state policy, and the Government have already acquired one of the two trunk lines constructed by private enterprise, and it is not likely that any further concessions in regard to railway construction will be granted to private persons.

Posts and Telegraphs.—The postal and telegraphic facilities offered by the various states are very considerable. There are some 5800 post offices supported by the different Governments, or about one office to every 600 persons. The letters carried amount to about 54 per head, the newspapers to 27 per head, and the packets to 10 per head. The length of telegraph lines in use is 42,200 miles, and the length of wire about 2½ times that distance. In 1899 there were about 7,745,000 telegraphic messages sent, which gives an average of two messages per inhabitant. The postal services and the telegraphs are administered by the Federal Government.

Banking.—Depositors in Savings Banks number about one-fourth of the whole population. In June 1900 the sum deposited was £27,111,360 to the credit of 851,000 persons. In the ordinary banks the amount on deposit was £86,959,208, of which £50,562,108 bore interest. In 1871 the deposits in the Savings Banks amounted to £3,003,393; in 1881, £7,524,186; in 1891, £14,982,175; and in 1899, £27,111,360.

RECENT HISTORY.

The history of Australia since 1873 is mainly comprised in its industrial progress, for, with the exception of the advent of the Labour party and the Federation Government, there have been no occurrences of such political importance as to call for special mention. The four eastern states had the privilege of responsible government bestowed on them at various dates between 1855 and 1860. After the establishment of responsible government the main questions at issue were the secular as opposed to the religious system of public instruction, protection as opposed to a revenue tariff, vote by ballot, manhood suffrage, abolition of transportation and assignment of convicts, and free selection of lands before survey; these, and indeed all the great questions upon which the country was divided, were settled before the year 1873. With the disposal of these important problems, politics in Australia became a struggle for office between men whose political principles were very much alike, and the tenure of power enjoyed by the various Governments did not depend upon the principles of administration so much as upon the personal fitness of the head of the ministry, and the acceptability of his ministry to the members of the more popular branch of the legislature. For the most part, therefore, the history of the colonies is a catalogue of their domestic events, such a thing as a foreign policy being quite unknown. The leading politicians of all the states have felt the cramping effects of mere domestic legislation, albeit on the proper direction of such legislation depends the well-being of the people, and to this sense of the limitations of local politics is due, as much as to anything else, the movement towards federation, now happily consummated.

Agrarian legislation.

Taking the states as a whole, agrarian legislation has been the most important subject that has engrossed the attention of their parliaments, and every state has been more or less engaged in tinkering with its land laws. The main object of all such legislation is to secure the residence of the owners on the land. The object of settlers, however, in a great many, perhaps in the majority of instances, is to dispose of their holdings as soon as possible after the requirements of the law have been complied with, and to avoid permanent settlement. This has greatly facilitated the formation of large estates devoted chiefly to grazing purposes, contrary to the policy of the legislature, which has everywhere sought to encourage tillage, or tillage joined to stock rearing, and to discourage large holdings. The importance of the land question is so great that it is hardly an exaggeration to say that it is usual for every parliament of Australia to have before it a proposal to alter or amend its land laws. Since 1870 there have been four radical changes made in New South Wales. In Victoria the law has been altered five times, and in Queensland and South Australia six times. Apart from the settlement of agrarian questions, recent Australian politics have concerned themselves with the prevention or regulation of the influx of coloured races, the prevention or settlement of labour disputes, and federation. The agitation against the influx of Chinese commenced very soon after the gold discoveries, the European miners objecting strongly to the presence of these aliens upon the diggings. The allegations made concerning the Chinese really amounted to a charge of undue industry. The Chinese were hard-working and had the usual fortune attending those who work hard. They spent little on drink or with the storekeepers, and were, therefore, by no means popular. As early as 1860 there had been disturbances of a serious character, and the Chinese were chased off the goldfields of New South Wales, serious riots occurring at Lambing Flat, on the Burrangong goldfield. The Chinese difficulty, so far as the mining population was concerned, was solved by the exhaustion of the extensive alluvial deposits; the miners' prejudice against the race, however, still exists, though they are no longer serious competitors, and the laws of some of the states forbid any Chinese to engage in mining without the express authority in writing of the Minister of Mines. The nearness of China to Australia has always appeared to the Australian democracy as a menace to the integrity of the white settlements; and at the many conferences of representatives from the various states, called to discuss matters of general concern, the Chinese question has always held a prominent place, but the absence of any federal authority has made common action difficult. In 1888 the last important conference on the Chinese question was held in Sydney and attended by delegates from all the states. Previously to the meeting of the conference there had been a great deal of discussion in regard to the influx of Chinese, and such influx was on all sides agreed to be a growing danger. The conference, therefore, merely expressed the public sentiment when it resolved that, although it was not advisable to prohibit altogether this class of immigration, it was necessary in the public interests that the number of Chinese privileged to land should be so limited as to prevent the people of that race from ever becoming an important element in the community. The New South Wales parliament was considering a Chinese Exclusion Bill when the conference of 1888 was summoned, and ultimately passed a law which in some respects went much beyond the agreement arrived at. Under the New South Wales law masters of vessels are forbidden, under a heavy penalty, to bring to the colony more than one Chinese to every 300 tons, and a poll-tax of £100 is charged on every Chinese landing. In Victoria, Queensland, and South Australia no poll-tax is imposed, but masters of vessels may bring only one Chinese to every 500 tons burden. West Australian legislation was until recently similar to that of the three last-named states, but has now been superseded by the Coloured Immigrants Restriction Act. Tasmania allows one Chinese passenger to every 100 tons, and imposes a poll-tax of £10. These

Chinese question.

stringent regulations have had the effect of greatly restricting the influx of Chinese, but in spite of all precautions there is still some immigration. The only other alien race present in large numbers in Australia are the Polynesians in Queensland, where they number about 9000. Of late years there has been an influx of Hindoos and other Eastern races, sufficiently large to cause a feeling of uneasiness amongst the colonists; and in some of the states the evil has been dealt with by parliament, and restrictive legislation has been passed which meted out to these immigrants somewhat similar treatment to that accorded to the Chinese. But a very large proportion of the Asiatics, whose entrance into the colonies it was desired to stop, were British subjects, and the Imperial Government refused to sanction any measure directly prohibiting in plain terms the movement of British subjects from one part of the empire to another. Eventually, the difficulty was overcome by the application of an educational test to the coloured races seeking admission to the states, whereby they are required to write out in some European language an application for permission to enter the colony in which they propose to reside. This provision is taken from an Act in operation in Natal, which is said to have been effectual in preventing an undue influx of Asiatics. An Act applying the educational test has been in force in West Australia since the beginning of 1898; more recently a similar Act was passed in New South Wales, while the other states have analogous legislation in operation. The agitation which this restrictive legislation caused was promoted and kept alive almost entirely by the trades unions, and was the first legislative triumph of the Labour party, albeit that party was not at the time directly represented in parliament.

Labour movement.

The Great Strike of 1890.

The Labour movement in Australia may be traced back to the early days when transportation was in vogue, and the free immigrant and the time-expired convict objected to the competition of the bond labourer. The great object of these early struggles being attained, Labour directed its attention mainly to securing shorter hours. It was aided very materially by the dearth of workers consequent on the gold discoveries, when every man could command his own price. When the excitement consequent on the gold finds had subsided, there was a considerable reaction against the claims of Labour, and this was greatly helped by the congested state of the labour market; but the principle of an eight-hours day made progress, and was conceded in several trades. In the early years of the 'seventies the colonies entered upon an era of well-being, and for about twelve years every man, willing to work and capable of exerting himself, readily found employment. The Labour unions were able to secure in these years many concessions both as to hours and wages. In 1873 there was an important rise in wages, in the following year there was a further advance, and another in 1876; but in 1877 wages fell back a little, though not below the rate of 1874. In 1882 there was a very important advance in wages; carpenters received 11s. a day, bricklayers 12s. 6d., stonemasons 11s. 6d., plasterers 12s., painters 11s., blacksmiths 10s., and navvies and general labourers 8s., and work was very plentiful. For five years these high wages ruled; but in 1886 there was a sharp fall, though wages still remained very good. In 1888 there was an advance, and again in 1889. In 1890 matters were on the eve of a great change and wages fell, in most cases to a point 20 per cent. below the rates of 1885. In 1893 came the bank crisis and great restriction in trade. Almost the first effect of this restriction was a reduction in wages, which touched their lowest in 1895, and fell to a point below that of any year since 1850. Since then there has been a marked recovery, and wages stood in 1900 at about the same level as in 1873. During the whole period from 1873 onwards, prices, other than of labour, have been steadily tending downwards, so that the cost of living in 1900 was much below that of 1873. Taking everything into consideration the reduction was, perhaps, not less than 40 per cent., so that though the nominal or money wages in 1873 and 1900 were the same, the actual wages were much higher in the latter year. Much of the improvement in the lot of the wage-earners has been due to the Labour organizations, yet so late as 1881 these organizations were of so little account, politically, that when the law relating to trades unions was passed in New South Wales, the English law was followed, and it was simply enacted that the purposes of any trades union shall not be deemed unlawful (so as to render a member liable to criminal prosecution for conspiracy or otherwise) merely by reason that they are in restraint of trade. After the year 1884 Labour troubles became very frequent, the New South Wales coal miners in particular being at war with the colliery owners during the greater part of the six years intervening between then and what is called the Great Strike. The strong downward tendency of prices made a reduction of wages imperative; but the labouring classes failed to recognize any such necessity, and strongly resented any reductions proposed by employers. It was hard indeed for a carter drawing coal to a gasworks to recognize the necessity which compelled a reduction in his wages because wool had fallen 20 per cent. Nor were other labourers, more nearly connected with the producing interests, satisfied with a reduction of wages because produce had fallen in price all round. Up to 1889 wages held their ground, although work had become more difficult to obtain, and some industries were being carried on without any profit. It was at such an inopportune time that the most extensive combination of Labour yet brought into action against capital formulated its demands. It is possible that the London dockers' strike was not without its influence on the minds of the Australian Labour leaders. That strike had been liberally helped by the Australian unions, and it was confidently predicted that, as the Australian workers were more effectively organized than the English unions, a corresponding success would result from their course of action. A strike of the Newcastle miners, after lasting twenty-nine weeks, came to an end in January 1890, and throughout the rest of the year there was great unrest in Labour circles. On 6th September the silver mines closed down, and a week later a conference of employers issued a manifesto which was met next day by a counter-manifesto of the Intercolonial Labour Conference, and almost immediately afterwards by the calling out of 40,000 men. The time chosen for the strike was the height of the wool season, when a cessation of work would be attended with the maximum of inconvenience. Sydney was the centre of the disturbance, and the city was in a state of industrial siege, feeling running to dangerous extremes. Riotous scenes occurred both in Sydney and on the coal-fields, and a large number of special constables were sworn in by the Government. Towards the end of October 20,000 shearers were called out, and many other trades, principally concerned with the handling or shipping of wool, joined the ranks of the strikers, with the result that the maritime and pastoral industries throughout the whole of Australia were most injuriously disturbed. The Great Strike, as it was called, terminated early in November 1890, the employers gaining a decisive victory. The colonies were, however, to have other and bitter experiences of strikes before Labour recognized that of all means for settling industrial disputes strikes are, on the whole, the most disastrous that it can adopt. The strikes of the years 1890 and 1892 are just as important on account of their political consequences as from the direct gains or losses involved.

Political consequences.

New South Wales.

As one result of the strike of 1890 a movement was set afoot by a number of enthusiasts, more visionary than practical, that has resulted in a measure of more or less disaster. This was the planting of a colony of communistic Australians in South America. After much negotiation the leader, Mr William Lane, a Brisbane journalist, decided on Paraguay, and he tramped across the continent, preaching a new crusade, and gathering in funds and recruits in his progress. On the 16th of July 1893 the first little army of "New Australians" left Sydney in the *Royal Tar*, which arrived at Monte Video on the 31st of August. Other consignments of intending settlers in "New Australia" followed; but though the settlement is still in existence it has completely failed to realize the impracticable ideals of its original members. The Queensland Government has assisted some of the disillusioned to escape from the paradise which has proved a prison; some managed to get away on their own account; and those that have remained have split into as many settlements almost as there are settlers. Another effect of the Great Strike was in a more practical direction. New South Wales was the first country which endeavoured to settle its labour grievances through the ballot-box and to send a great party to parliament as the direct representation of Labour, pledged to obtain through legislation what it was unable to obtain by strikes and physical force. The principle of one-man one-vote had been persistently advocated without arousing any special parliamentary or public enthusiasm until the meeting of the Federal Convention in 1891. The convention was attended by Sir George Grey, who was publicly welcomed to the colony by New Zealanders resident in Sydney, and by other admirers, and his reception was an absolute ovation. He eloquently and persistently advocated the principle of one-man one-vote as the bed-rock of all democratic reform. This subsequently formed the first plank of the Labour platform. Several attempts had been made by individuals belonging to the Labour party to enter the New South Wales parliament, but it was not until 1891 that the occurrence of a general election gave the party the looked-for opportunity for concerted action. The results of the election came as a complete surprise to the majority of the community. The Labour party captured 35 seats out of a House of 125 members; and as the old parties almost equally divided the remaining seats, and a fusion was impossible, the Labour representatives dominated the situation. It was not long, however, before the party itself became divided on the fiscal question; and a Protectionist Government coming into power, about half the Labour members gave it consistent support and enabled it to maintain office for about three years, the party as a political unit being thus destroyed. The events of these three years taught the Labour leaders that a parliamentary party was of little practical influence unless it was able to cast on all important occasions a solid vote, and to meet the case a new method was devised. The party therefore determined that they would refuse to support any person standing in the Labour interests who refused to pledge himself to vote on all occasions in such way as the majority of the party might decide to be expedient. This was called the "solidarity pledge," and, united under its sanction, what was left of the Labour party contested the general election of 1894. The result was a defeat, their numbers being reduced from 35 to 19; but a signal triumph was won for solidarity. Very few of the members who refused to take the pledge were returned, and the adherents of the united party were able to accomplish more with their reduced number than under the old conditions.

The two features of the Labour party in New South Wales are its detachment from other parties and the control of the caucus. The caucus, which is the natural corollary of the detachment, determines by majority the vote of the whole of the members of the party, independence of action being allowed on minor questions only. So far the party has refrained from formal alliance with the other great parties of the state. It supports the Government as the power alone capable of promoting legislation, but its support is given only so long as the measures of the Government are consistent with the Labour policy. This position the Labour party has been able to maintain with great success, owing to the circumstance that the other parties have been almost equally balanced.

Other colonies.

The movement towards forming a parliamentary Labour party was not confined to New South Wales; on the contrary, it was common to all the colonies except West Australia, and its greatest triumphs have been achieved in New Zealand and South Australia. Like the organization in New South Wales, the Labour party of South Australia owes its origin to the failure of the Great Strike of 1890. In that year the Trades and Labour Council of Adelaide summoned a conference of Labour representatives, at which a proposal for the formation of a parliamentary party was drawn up and adopted. The political programme of the new party was comprehensive and popular, and almost immediately on its adoption three representatives of Labour won seats in the Second Chamber (Legislative Council), and at the ensuing general election of 1893 the party secured 8 seats in the assembly out of a total of 54, and 6 out of 24 in the council, thereby gaining a controlling vote in both Houses. Two general elections have since taken place, and at each the party has maintained its position. In 1900 it controlled 12 votes in the popular House and 8 in the council. The members of the South Australian Labour party differ in one important respect from those of New South Wales. They are all persons who have worked for their living at manual labour, and this qualification of being an actual worker is one that was strongly insisted upon at the formation of the party and strictly adhered to, although the temptation to break away from it and to accept as candidates persons of superior education and position has been very great. The South Australian Labour party has maintained the unity of its ranks, notwithstanding the fact that several of its members hold very diverse views on important questions of political reform, and it recently showed its power by displacing the Government of the Right Honourable C. C. Kingston, and almost immediately afterwards ousting that of Mr V. L. Solomon, who succeeded Mr Kingston in the premiership. In Victoria the Labour party has not been so conspicuous as in New South Wales and South Australia. The members of the Victorian Assembly are not divided into such distinct parties as are the members of the popular houses of the other colonies, and the Labour party has therefore not been able to determine the real balance of power. Nevertheless it wields an influence that is very much respected, as is evidenced by the large amount of advanced democratic legislation which has been proposed by the various governments that have held office since 1890, even by governments with strong Conservative leanings. In Queensland the Labour party numbered, in 1900, 21 out of 72 members in the elective branch of parliament, a larger proportion than in any other state; but only for a brief period have parties been so evenly divided as to give the Labour party the balance of power.

The brief period mentioned was towards the close of 1899, when dissatisfaction had spread amongst the supporters of the Government of Mr Dickson. That Government was displaced on a motion moved by the leader of the Labour party, Mr Dawson, supported by the Opposition and by a number of members usually voting with the Government. Mr Dawson was called on to form a government. He did so, and his ministry held office for only two days, giving place to a government including all the leading members of the previous administration, as well as the leader of the former Opposition.

Australian Federation.—The question of federation was not lost sight of by the framers of the original constitution which was bestowed upon New South Wales. In the report of the committee of the Legislative Council appointed in 1852 to prepare a constitution for that colony, the following passage occurs:—"One of the most prominent legislative measures required by the colony, and the colonies of the Australian group generally, is the establishment at once of a General Assembly, to make laws in relation to those intercolonial questions that have arisen or may hereafter arise among them. The questions which would claim the exercise of such a jurisdiction appear to be (1) intercolonial tariffs and the coasting trade; (2) railways, roads, canals, and other such works running through any two of the colonies; (3) beacons and lighthouses on the coast; (4) intercolonial gold regulations; (5) postage between the said colonies; (6) a general court of appeal from the courts of such colonies; (7) a power to legislate on all other subjects which may be submitted to them by addresses from the legislative councils and assemblies of the colonies, and to appropriate to any of the above-mentioned objects the necessary sums of money, to be raised by a percentage on the revenues of all the colonies interested." This wise recommendation received very scant attention, and it was not until the necessities of the colonies forced them to it that an attempt was made to do what the framers of the original constitution suggested. Federation at no time actually dropped out of sight, but it was not until thirty-five years later that any practical steps were taken towards its accomplishment. Meanwhile a sort of makeshift was devised, and the Imperial Parliament passed a measure permitting the formation of a Federal Council, to which any colony that felt inclined to join could send delegates. Of the seven colonies New South Wales and New Zealand stood aloof from the council, and from the beginning it was therefore shorn of a large share of the prestige that would have attached to a body speaking and acting on behalf of a united Australia. The council had also a fatal defect in its constitution. It was merely a deliberative body, having no executive functions and possessing no control of funds or other means to put its legislation in force. Its existence was well-nigh forgotten by the people of Australia until the occurrence of its biennial meetings, and even then but slight interest was taken in its proceedings. The council held eight meetings, at which many matters of intercolonial interest were discussed. The last occasion of its being called together was in 1899, when the council met in Melbourne. In 1889 an important step towards federation was taken by Sir Henry Parkes. The occasion was the report of Major-General Edwards on the defences of Australia, and Sir Henry addressed the other premiers on the desirability of a federal union for purposes of defence. The immediate result was a conference at Parliament House, Melbourne, of representatives from each of the seven colonies. This conference adopted an address to the Queen expressing its loyalty and attachment, and submitting certain resolutions which affirmed the desirability of an early union, under the Crown, of the Australasian colonies, on principles just to all, and provided that the remoter Australasian colonies should be entitled to admission upon terms to be afterwards agreed upon, and that steps should be taken for the appointment of delegates to a national Australasian convention, to consider and report upon an adequate scheme for a federal convention. In accordance with the understanding arrived at, the various Australasian parliaments appointed delegates to attend a national convention to be held in Sydney, and on the 2nd March 1891 the convention held its first meeting. Sir Henry Parkes was elected president, and he moved a series of resolutions embodying the principles necessary to establish, on an enduring foundation, the structure of a federal government. These resolutions were slightly altered by the conference, and were adopted in the following form:—

History of federation movement.

1. The powers and rights of existing colonies to remain intact, except as regards such powers as it may be necessary to hand over to the Federal Government.
2. No alteration to be made in states without the consent of the legislatures of such states, as well as of the federal parliament.
3. Trade between the federated colonies to be absolutely free.
4. Power to impose customs and excise duties to be in the Federal Government and parliament.
5. Military and naval defence forces to be under one command.
6. The federal constitution to make provision to enable each state to make amendments in the constitution if necessary for the purposes of federation.

Other formal resolutions were also agreed to, and on the 31st of March Sir Samuel Griffith, as chairman of the committee on constitutional machinery, brought up a draft Constitution Bill, which was carefully considered by the convention in committee of the whole and adopted on the 9th of April, when the convention was formally dissolved. The Bill, however, fell absolutely dead. Not because it was not a good Bill, but because the movement out of which it arose had not popular initiative, and therefore failed to reach the popular imagination. Even its authors recognized the apathy of the people, and parliamentary sanction to its provisions was not sought in any colony.

Although the Bill drawn up by the convention of 1891 was not received by the people with any show of interest, the federation movement did not die out; on the contrary, it had many enthusiastic advocates, especially in the colony of Victoria. In 1894 an unofficial convention was held at Corowa, at which the cause of federation was strenuously advocated, but it was not until 1895 that the movement obtained new life, by reason of the proposals adopted at a meeting of Premiers convened by Mr G. H. Reid of New South Wales. At this meeting all the colonies except New Zealand were represented, and it was agreed that the parliament of each colony should be asked to pass a Bill enabling the people to choose ten persons to represent the colony on a federal convention; the work of such convention being the framing of a federal constitution to be submitted to the people for approval by means of the referendum. During the year 1896 Enabling Acts were passed by New South Wales, Victoria, Tasmania, South Australia, and West Australia, and delegates were elected by popular vote in all the colonies named except West Australia, where the delegates were chosen by parliament. The convention met in Adelaide on the 22nd of March 1897, and, after drafting a Bill for the consideration of the various parliaments, adjourned until the 2nd September. On that date the delegates reassembled in Sydney, and debated the Bill in the light of the suggestions made by the legislatures of the federating colonies. In the course of the proceedings it was announced that Queensland desired to come within the proposed union; and in view of this development, and in order to give further opportunity for the consideration of the Bill, the convention again adjourned. The third and final session was opened in Melbourne on the 20th of January 1898, but Queensland was still unrepresented; and, after further consideration, the draft Bill was finally adopted on the 16th of March and remitted to the various colonies for submission to the people.

Bill of 1898.

In its main provisions the bill of 1898 followed generally that of 1891, yet with some very important alterations. It proposed to establish, under the Crown, a federal union of the Australasian colonies, to be designated the Commonwealth of Australia. A federal executive council was created, to be presided over by a governor-general appointed by the Sovereign. The legislature was to consist of two houses—a Senate, in which each colony joining the federation at its inception was conceded the equal representation of six members; and a House of Representatives, to consist of, as nearly as possible, twice the number of senators, to which the provinces were to send members in proportion to population, with a minimum of five representatives for each of the original federating states. The principle of payment of members was adopted for the Senate as well as the House of Representatives. The nominative principle for the upper house was rejected, both houses being elective, on a suffrage similar to that existing in each colony for the popular chamber at the foundation of the Commonwealth. The House of Representatives was to be elected for a period of three years, the term of office of senators was twice that period, but half the Senate was to retire every three years. The capital of the Commonwealth was to be established in federal territory. To the federal authority was assigned power to deal with a large number of matters, with the provision that in case of conflict between federal and state law the former should prevail. Customs and excise were to be taken over on the establishment of the Commonwealth, and posts and telegraphs, naval and military defence, lighthouses and lightships, beacons and buoys, and quarantine, on dates to be proclaimed, but without further legislation. A uniform tariff of customs and excise was to be imposed within a period of two years, intercolonial trade then becoming absolutely free. Besides these were many subsidiary provisions usually found in federal constitutions, and provisions of a special character such as were needed to meet the peculiar conditions of the Australian states.

The constitution was accepted by Victoria, South Australia, and Tasmania by popular acclamation, but in New South Wales very great opposition was shown, the main points of objection being the financial provisions, equal representation in the Senate, and the difficulty in the way of the larger states securing an amendment of the constitution in the event of a conflict with the smaller states. As far as the other colonies were concerned, it was evident that the Bill was safe, and public attention throughout Australia was fixed on New South Wales, where a fierce political contest was raging, which it was recognized would decide the fate of the measure for the time being. The fear was as to whether the statutory number of 80,000 votes necessary for the acceptance of the Bill would be reached. This fear proved to be well founded, for the result of the referendum in New South Wales showed 71,595 votes in favour of the Bill and 66,228 against it, and it was accordingly lost. In Victoria, Tasmania, and South Australia, on the other hand, the Bill was accepted by triumphant majorities. West Australia did not put it to the vote, as the Enabling Act of that colony only provided for joining a federation of which New South Wales should form a part. The existence of such a strong opposition to the Bill in the mother colony convinced even its most zealous advocates that some changes would have to be made in the constitution before it could be accepted by the people; consequently, although the general election in New South Wales, held six or seven weeks later, was fought on the federal issue, yet the opposing parties seemed to occupy somewhat the same ground, and the question narrowed itself down to one as to which party should be entrusted with the negotiations to be conducted on behalf of the colony, with a view to securing a modification of the objectionable features of the Bill. The new parliament decided to adopt the procedure of again sending the Premier, Mr Reid, into conference, armed with a series of resolutions affirming its desire to bring about the completion of federal union, but asking the other colonies to agree to the reconsideration of the provisions which were most generally objected to in New South Wales. The other colonies interested were anxious to bring the matter to a speedy termination, and readily agreed to this course of procedure. Accordingly a Premiers' conference was held in Melbourne at the end of January 1899, at which Queensland was for the first time represented. At this conference a compromise was effected, something was conceded to the claims of New South Wales, but the main principles of the Bill remained intact. The Bill as amended was submitted to the electors of each colony and again triumphantly carried in Victoria, South Australia, and Tasmania. In New South Wales and Queensland there were still a large number of persons opposed to the measure, which was nevertheless carried in both colonies. New South Wales having decided in favour of federation, the way was clear for a decision on the part of West Australia. The Enabling Bill passed the various stages in the parliament of that colony, and the question was then submitted by way of referendum to the electors. The result of the voting (in five colonies in 1899, and in West Australia in 1900), was as follows:—

Premiers' conference, 1899.

		1899.
New South Wales	for	107,420
	against	82,741
Victoria	for	152,653
	against	9,804
Queensland	for	38,181
	against	28,965
South Australia	for	65,990
	against	17,053
West Australia (1900)	for	44,704
	against	19,691
Tasmania	for	13,437
	against	791

In accordance with this verdict, the colonial draft Bill was submitted to the Imperial Government for legislation as an Imperial Act; and six delegates were sent to England to explain the measure and to pilot it through the Cabinet and Parliament. These delegates were—Mr Barton (New South Wales), Mr Deakin (Victoria), Mr Kingston (South Australia), Mr Dickson (Queensland), Mr Parker (West Australia), and Sir Philip Fysh (Tasmania).

Commonwealth Act, 1900.

Under an Act of the British Parliament, dated 9th July 1900, passed under the auspices of Mr Chamberlain, Secretary of State for the colonies, a proclamation was issued, 17th September of the same year, declaring that, on and after 1st January 1901, the people of New South Wales, Victoria, South Australia, Queensland, Tasmania, and West Australia should be united in a Federal Commonwealth under the name of the Commonwealth of Australia. The Act which gave authority for the issue of this proclamation embodied and established (with such variations as had been accepted on behalf of the colonies) the constitution agreed to at the Premiers' conference of 1899. It was cordially welcomed in the mother country, and though its passage was marked by certain difficulties, finally became law amid signs of general approval. The difficulties arose with regard to the right of appeal to the Queen in Council. By clause 74 of the original Bill this right was very seriously curtailed; Mr Chamberlain wished to preserve it as in the case of Canada, while, in order to disarm colonial opposition, he suggested that the judicial committee of the Privy Council should be strengthened by the appointment of four colonial members with the rank of lords of appeal. But after privately conferring with the Australian delegates he withdrew this suggestion, and when the second reading of the Bill came on he announced that a compromise had been agreed upon. The final form of the disputed clause provided that in cases which involved non-Australian interests the right of appeal should be fully maintained, and that in questions between the Commonwealth and a single state, or between two states, leave to appeal might be given by the High Court of Australia. Mr Chamberlain indicated that this matter might receive further development at a future time, and that it was possible that after consulting with the colonies the Government might propose the establishment of a permanent court of appeal for the whole empire. Soon after the passage of the Bill the choice of governor-general of the new Commonwealth fell upon Lord Hopetoun, who had won golden opinions as governor of Victoria a few years before; Mr Barton, who had taken the lead among the Australian delegates, became first Prime Minister; and the Commonwealth was successfully inaugurated at the opening of 1901.

Provisions of the Act.

The six colonies entering the Commonwealth were denominated original states, and new states might be admitted, or might be formed by separation from or union of two or more states or parts of states; and territories (as distinguished from states) might be taken over and governed under the legislative power of the Commonwealth. The legislative power is vested in a federal parliament, consisting of the Sovereign, a senate, and a house of representatives, the Sovereign being represented by a governor-general. The Senate was to consist of the same number of members (not less than six) for each state, the term of service being six years, but subject to an arrangement that half the number would retire every three years. The House of Representatives was to consist of members chosen in the different states in numbers proportioned to their population, but never fewer than five. The first House of Representatives was to contain seventy-five members. For elections to the Senate the governors of states, and for general elections of the House of Representatives the governor-general, would cause writs to be issued. The Senate would choose its own President, and the House of Representatives its Speaker; each house would make its own rules of procedure; in each, one-third of the number of members would form a quorum; the members of each must take oath, or make affirmation of allegiance; and all alike would receive an allowance of £400 a year. The legislative powers of the parliament have a wide range, many matters being transferred to it from the colonial parliaments. The more important subjects with which it deals are trade, shipping, and railways; taxation, bounties, the borrowing of money on the credit of the Commonwealth; the postal and telegraphic services; defence, census, and statistics; currency, coinage, banking, bankruptcy; weights and measures; copyright, patents, and trade marks; marriage and divorce; immigration and emigration; conciliation and arbitration in industrial disputes. Bills imposing taxation or appropriating revenue must not originate in the Senate, and neither taxation Bills nor Bills appropriating revenue for the annual service of the Government may be amended in the Senate, but the Senate may return such Bills to the House of Representatives with a request for their amendment. Appropriation laws must not deal with other matters. Taxation laws must deal with only one subject of taxation; but customs and excise duties may, respectively, be dealt with together. Votes for the appropriation of the revenue shall not pass unless recommended by the governor-general. The constitution provides means for the settlement of disputes between the houses, and requires the assent of the Sovereign to all laws. The executive power is vested in the governor-general, assisted by an executive council appointed by himself. He has command of the army and navy, and appoints federal ministers and judges. The ministers are members of the executive council, and must be, or within three months of their appointment must become, members of the parliament. The judicial powers are vested in a high court and other federal courts, and the federal judges hold office for life or during good behaviour. The High Court has appellate jurisdiction in cases from other federal courts and from the supreme courts of the states, and it has original jurisdiction in matters arising under laws made by the federal parliament, in disputes between states, or residents in different states, and in matters affecting the representatives of foreign powers. Special provisions were made respecting appeals from the High Court to the Sovereign in council. The constitution set forth elaborate arrangements for the administration of finance and trade during the transition period following the transference of departments to the Commonwealth. Within two years uniform customs duties were to be imposed; thereafter the parliament of the Commonwealth had exclusive power to impose customs and excise duties, or to grant bounties; and trade within the Commonwealth was to be absolutely free. Exceptions were made permitting the states to grant bounties on mining and (with the consent of the parliament) on exports of produce or manufactures—West Australia being for a time partially exempted from the prohibition to impose import duties.

The constitution, parliament, and laws of each state, subject to the federal constitution, retained their authority; state rights were carefully safeguarded, and an inter-state commission was given powers of adjudication and of administration of the laws relating to trade, transport, and other matters. Provision was made for necessary alteration of the constitution of the Commonwealth, but so that no alteration could be effected unless the question had been directly submitted to, and the change accepted by the electorate in the states. The seat of government was to be within New South Wales, not less than 100 miles distant from Sydney, and of an area not less than 100 square miles. Until other provision was made, the governor-general was to have a salary of £10,000, paid by the Commonwealth. Respecting the salaries of the governors of states, the constitution made no provision.

AUTHORITIES.—**For Physical Geography**: BARTON. *Australian Physiography*. Brisbane, 1895.—WALL. *Physical Geography of Australia*. Melbourne, 1883.—TAYLOR. *Geography of New South Wales*. Sydney, 1898.—SAVILLE KENT. *The Great Barrier Reef of Australia*. London, 1893.—AGASSIZ. *Visit to the Barrier Reef*. Cambridge, Mass., 1899.—THOMSON, J. P. *The Physical Geography of Australia* (Smithsonian Report). Washington, 1898. **For Geology**: M'COY. *Palæontology of Victoria*. Melbourne, 1874-1882.—DARWIN. *Geological Observations*. 2nd edition, London, 1876.—CLARKE. *Sedimentary Formations of New South Wales*. Sydney, 1878.—JOHNSTON. *Geology of Tasmania*. Hobart, 1888.—ETHERIDGE and JACK. *Geology and Palæontology of Queensland*. Brisbane, 1892.—WOODWARD. *Mining Handbook to the Colony of Western Australia*. Perth, 1894.—CURRAN. *Geology of Sydney and the Blue Mountains*. Sydney, 1899. **For Flora**: MAIDEN. *Useful Native Plants of Australia*. Sydney, 1889.—BENTHAM and MUELLER. *Flora Australiensis*. London, 1863-78.—FITZGERALD. *Australian Orchids*. Sydney, 1870-90.—MUELLER. *Census of Australian Plants*. Melbourne, 1889. **For Fauna**: FORBES. "The Chatham Islands; their Relation to a former Southern Continent," *Geographical Journal*, vol. ii., 1893.—HEDLEY. "Surviving Refugees in Austral Lands of Ancient Antarctic Life," *Royal Society N. S. Wales*, 1895; "The Relation of the Fauna and Flora of Australia to those of New Zealand," *Nat. Science*, 1893.—TENISON-WOODS. *The Fish and Fisheries of New South Wales*. Sydney, 1883.—OGILBY. *Catalogue of Australian Mammals*. Sydney, 1892.—AFLALO. *Natural History of Australia*. London, 1896.—FLOWER and LYDEKKER. *Mammals, Living and Extinct*. London, 1891.—OGILBY, J. DOUGLAS. *Catalogue of the Fishes of New South Wales*, 4to, Sydney, 1886. **For Aborigines**: WALLACE. *Australasia*, 1893.—ROTH. *Queensland Aborigines*. Brisbane, 1897.—LUMHOLTZ. *Among Cannibals*. London, 1890.—MATTHEW. *Eaglehawk and Crow*. London, 1899.—SPENCER and GILLEN. *Native Tribes of Central Australia*. London, 1899.—HOWITT. Australian Association address, 1893. Sydney, 1894.—CURR, E. M. *The Australian Race: its Origin, Languages, Customs, &c.*, 4 vols. Melbourne, 1886-87.—FISON, LORIMER, and HOWITT, A. W. *Kamilaroi and Kurnai, Group Marriage, and Relationship, &c.*, 8vo. Melbourne, 1880. **For Statistics and Miscellanea**: COGHLAN, T. A. *A Statistical Account of the Seven Colonies of Australasia*, 8vo. Sydney, 1898.—COLLINGRIDGE, G. *The Discovery of Australia*. Sydney, 1895.—EPPS, W. *The Land Systems of Australia*, 8vo. London, 1894.—FAVENC, ERNEST. *The History of Australasian Exploration*, royal 8vo. Sydney, 1885.—GARRAN, R. R. *The Coming Commonwealth; a Handbook of Federal Government*. Sydney, 1897.—RUSDEN, GEORGE WILLIAM. *History of Australia*, 3 vols. 8vo. London, 1883.—SCHMEISSER, K. *The Goldfields of Australasia*, 2 vols. London, 1899.—SCOTT, G. F. *The Romance of Australian Exploring*. London, 1899.—WALKER, H. DE R. *Australasian Democracy*. London, 1897.—WESTGARTH, WILLIAM. *Half a Century of Australian Progress*. London, 1889.

(J. M. Cu.; T. A. C.)

END OF FIRST VOLUME.

Printed by R. & R. CLARK, LIMITED, *Edinburgh*.

BOUND IN LIBRARY.
JUL 28 1908

UNIVERSITY OF MICHIGAN
3 9015 07418 8759

Google

Google